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The Association of Gender and Socioeconomic Position with Cardiorespiratory Fitness in Adolescents

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Abstract

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Quentin M. Oliphant

MS, United States Sports Academy, 1997

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Dissertation Submitted in Partial Fulfillment

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Doctor of Philosophy

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Abstract

This meta-analysis investigated the association of gender and socioeconomic position with cardiorespiratory fitness in adolescents. Public health professionals know the importance of physical activity level as a modifiable behavior; however, the literature has revealed that more research is needed on the association of sociodemographic variables like gender and socioeconomic position with cardiorespiratory fitness in adolescents. Using the physical fitness and health outcomes conceptual model as a guide, the overall effect sizes across studies were assessed as well as the moderators of study design, sample size, age, and country. A systematic review of literature identified a total of 18 peer-reviewed studies meeting inclusion criteria, which yielded a total of 41 unique effect sizes. Meta-analysis utilizing a random effects model indicated that gender and socioeconomic position are associated with cardiorespiratory fitness and that age and country moderated these effects. The positive social change implication of this meta-analysis may provide evidence-based knowledge to public health officials, physical educators, and health educators who are considering changes in school health promotion policies and health promotion interventions geared toward different gender and socioeconomic groups. Long term results include increased physical activity, decreased clustered cardiovascular risk factors, and lowered all-cause and cardiovascular disease mortality as adolescents track into adulthood.

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Dedication

This project is dedicated to a host of family and friends who have provided me with support during this challenging but rewarding process. I would also like to dedicate this to current and former students who have allowed me the opportunity to become a better teacher. Without your support, I could not have accomplished this endeavor.

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Chapter 1: Introduction to the Study

Chronic diseases are the leading cause of morbidity and mortality in the United States (US) and most industrialized nations (Halpin, Morales-Suárez-Valera, & Martin-Moreno, 2010). Over the past two decades, cardiovascular diseases, diabetes mellitus, obesity, and certain cancers have had a negative worldwide impact (Halpin et al., 2010). Contributing factors associated with increased chronic disease are declining physical activity (PA) and decreased fitness levels (Carter & Micheli, 2013; Landry & Driscoll, 2012). Epidemiological evidence has indicated that physical activity (PA) levels have declined in students with each advancing grade level (Centers for Disease Control and Prevention [CDC], 2012). Evidence from the US has also revealed variability among sexes, races, and ethnicities in the proportion of youths who do not engage in PA. More specifically, female students tend to be less active than do male students (~18% and 10%, respectively; CDC, 2012). Additionally, Black female students (~27%) tend to be less active than do Black male students (~12%); Hispanic female students (21.3%) tend to be less active than do Hispanic male students (~11%); and, comparatively, non-Hispanic White males (8.5%) and females (~14%) tend to have the lowest prevalence of physical activity (CDC, 2012). Likewise, limited studies have shown ethnic/racial differences about cardiorespiratory fitness (CRF) levels in youths (Andreacci et al., 2004, 2005; Trowbridge et al., 1997).

Past reviews have tracked physical activity levels over time and concluded that there was low-to-moderate short-term tracking of physical activity (Friedman et al., 2008; Malina, 1996); however, limited studies have tracked the health-related physical fitness of youths since the 1980s (Pate, 1989; Plowman et al., 2006). Furthermore, limited studies have been used to examine whether race/ethnicity is associated with physical fitness in prepubescent and adolescent youths (Andreacci et al., 2004, 2005; Ponthieux & Barker, 1965). Ponthieux and Barker (1965) performed a study to examine the association of race with physical fitness and used the Youth Fitness Test from the American Alliance for Health, Physical Education, Recreation and Dance. The study consisted of school-aged Black and White children. A majority of participants were White, and there were 304 boys and 429 girls. The sample age range was between 10 and 12 years and was stratified by gender. The correlational analysis revealed that Black boys significantly exceeded the White boys in five out of eight fitness components, and the Black girls exceeded the White girls in four out of eight fitness components (p <. 05).

Andreacci et al. (2004, 2005) performed a cross-sectional analyses and found that Black prepubescent and pubescent youths had lower $VO_{2\ max}$ (aerobic capacity or CRF) when compared to White youths. Both studies indicated that age and race explained a large amount of the variance for these differences in VO_2 max between the races. However, ethnic groups (e.g., Hispanics) were not evaluated, and the sample size calculation was not presented in either study, which could lead to lowered statistical power. With this in mind, more research is needed to investigate the moderating effect of race/ethnicity on CRF.

Along with ethnicity and race, gender may be another variable associated with CRF. Based on the aforementioned results, it appears that gender differences exist even within different ethnic and racial groups. Pate, Oria, and Pillsbury (2012) found insufficient data available to assess how gender influenced CRF. However, they did not examine cross-sectional studies to note how gender impacted CRF, which could mean that gender is in some way associated with CRF. Ceasar, Fitzhugh, Thompson, and Bassett (2013) stated that there is still a need for more clarity about the degree of association between sociodemographic variables, such as gender and CRF. As such, it is worth examining cross-sectional studies to note gender's overall effect on CRF.

Socioeconomic status (SES) has also been shown to be closely linked with health status (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010). Limited studies have been used to examine the association between socioeconomic position (SEP)/SES and CRF among youths (Ceasar, Fitzhugh, Thompson, & Bassett, 2013). With this in mind, a meta-analysis will be performed on cross-sectional studies that have been used to examine this association. More specifically, one setting in which CRF and physical activity interventions have historically taken place is in schools (Pate, 1989).

Schools provide an optimal place to conduct physical fitness assessments and physical activity interventions because youths spend a majority of their time in school during the day (Naylor & McKay, 2008). To my knowledge, limited peer-reviewed studies have been used to examine health-related physical fitness at the school level to determine the effectiveness of physical education (PE) curriculum and instruction. This is due, in part, to the continued debate over whether fitness should be tested in schools (Lloyd, Colley, & Tremblay, 2010; Rowland, 1995). Those who oppose school-based physical fitness testing have suggested that physical fitness assessment is not as important as focusing on and assessing physical activity behaviors (Cale, Harris, & Chen, 2007;

Rowland, 1995), but others have suggested that physical fitness testing (if used appropriately) is essential if we are to know the current fitness levels of youths (Morrow, 2005; Silverman, Keating, & Phillips, 2008). Lloyd et al. (2010) proposed their hybrid model by arguing that physical fitness should continue to be assessed, but physical activity, motor skills, knowledge awareness, and understanding are also important aspects of being physically literate.

Current evidence shows a positive correlation between physical activity and physical fitness (U.S. Department of Health and Human Services, 2008). Research by Ekelund et al. (2007) supported this view in their findings by concluding that physical activity and fitness in youth are independently associated with metabolic health, but they may affect health through different pathways. Therefore, physical fitness components, such as CRF, should also be assessed. Furthermore, reports have shown that screening for problematic fitness deficiencies in adolescence may be beneficial due to the tracking of some risk factors associated with health markers (i.e., poor fitness) in adulthood (Kokkinos & Myers, 2010; Pate, 1989). If physical fitness is truly a marker of health, as proposed by Ortega, Ruiz, Castillo, and Sjöström (2008), physical educators and others who promote public health should assess and track health-related physical fitness.

However, despite the importance of health-related physical fitness (e.g., CRF) as an important marker of cardiovascular health, the assessment of fitness components related to health has not been routinely performed (Kaminsky et al., 2013). With that in mind, the purposes of this meta-analysis was to integrate and pool the results of current single researchers who have investigated the role of gender and SEP in CRF of adolescents (11–18 years old). Determining the associations of gender and SEP with CRF in adolescents could provide evidence-based knowledge to public health officials, physical educators, and health educators who are considering changes in school health promotion policies. These policies would include those about implementing health promotion interventions that reach adolescents who are from different socioeconomic groups and different genders. Long-term results would include increased physical activity, decreased clustered cardiovascular risk factors, and lowered all-cause and cardiovascular disease mortality in adulthood.

Chapter 1 provides a background for the study, followed by a statement of the problem, purpose statement, research questions/hypotheses, the nature of the study, conceptual framework, assumptions, limitations, delimitations, and significance of this investigation. Chapter 1 also shows why the criterion-referenced tests have been favored over norm-referenced fitness tests for the assessment of fitness. Lastly, an overview of Chapter 1 is provided, as well as a transition into Chapter 2.

Background

State Bill 530 (Cooper et al., 2010) and Texas Education Code §38.101 mandated all school districts to assess the physical fitness status of students in Grades 3 through 12 who are enrolled in PE or an approved substitute (Human Kinetics, 2014). State Bill 530 also mandates that a criterion-referenced standard assessment that is gender- and age-specific be used to assess the health-related physical fitness components of cardiorespiratory endurance, muscular strength, muscular endurance, body composition, and flexibility (Cooper et al, 2010). Texas legislators chose the criterion-based and computerized FITNESSGRAM®, a health-related physical fitness assessment program, to assess youths in these five areas of health-related physical fitness (Cooper et al., 2010).

Physical educators and teachers in school districts are responsible for administering all portions of the FITNESSGRAM® (Cooper et al., 2010). Once the data are collected, they are entered into the computerized database and sent to the Texas Education Agency, which is responsible for analyzing and summarizing/aggregating the data based on grade levels and genders. State law prohibits the identification of individuals and removes identifiers for confidentiality reasons (Welk, Meredith, Ihmels, & Seeger, 2010). That study is the only one I know of that examines distributional differences in health-related physical fitness among Texas youths. One health-related fitness component that Welk et al. (2010) assessed was CRF. They examined the distributional differences of health-related physical fitness of youths in Texas elementary schools, middle schools, and high schools. The analysis showed age-related declines in the percentage of youths who were in the Healthy Fitness Zone (HFZ) for CRF. The lowest results were found among middle school (46%) and high school (34%) students, but elementary students had the highest percentage of achievement of the HFZ (70%). An obvious gap mentioned by Welk et al. was a lack of studies concerning the “patterns and trends in health-related fitness [from Texas schools]” (p. S6). The authors then stated that “[c]oordinated school-based fitness testing is a way to obtain detailed state and regional information about health-related fitness” (p. S6). However, this information may not reflect the patterns and trends in different settings or with different populations.

The emphasis on CRF is significant because it has been shown to reduce all-cause mortality (Lee et al., 2011). A recent study by Gahche et al. (2014) reported that only 40% of 14 and 15 year olds in the US had adequate levels of CRF. A subgroup analysis revealed that boys were significantly more fit (49.1%) than were girls (31.8%; $p = < 0.05$). However, Gahche et al. also reported that teenagers do not differ significantly when race/ethnicity or family income (as measured by family income-to-poverty ratio) were considered for those who were considered fit. One weakness with Gahche et al.'s study is that they did not include information about interactions among race/ethnicity, gender, and family income-to-poverty ratio that could have confounded the results. Overall, Gahche et al. reported a decrease in CRF from 52.4% to 42.2% (~10 percentage points) from 2001–2002 to 2012.

Ortega, Ruiz, Castillo, and Sjöström (2008) reported in their literature review that CRF is a strong and independent marker of cardiovascular health. Based on this, public health professionals (e.g., physical educators and health educators) need field-based CRF and other health-related fitness tests that provide information about the likelihood of a disease outcome based on fitness levels (Lobelo, Pate, Dowda, Liese, & Ruiz, 2009; Ruiz et al., 2011; Welk, Laurson, Eisenmann, & Cureton, 2011). Using reliable and validated criterion-based CRF assessments allow researchers to determine whether adolescents are fit or unfit, based on their meeting predetermined standards (Lobelo et al., 2009). Based on this, efforts should be made to investigate the roles of certain sociodemographic factors that may be associated with CRF and cardiometabolic health.

Some could assume that gender and SEP are related to CRF in adolescents, but Ceasar et al. (2013) stated that there is still a need for more clarity about the degrees of association among sociodemographic variables, such as gender, socioeconomic indicators, and CRF. Statistically pooling available data from primary studies could provide an assessment of whether associations exist between these variables and whether CRF is important. Performing this meta-analysis will close the gap by providing public health professionals and other stakeholders with evidence needed to inform public and school health policy decisions. CRF has such an effect on cardiovascular health, so it seems appropriate to investigate the pooled effect size of multiple primary studies that focus on the association of gender, SEP, and CRF; however, I am unaware of meta-analytic studies that have focused on whether certain sociodemographic variables are associated with CRF. The need for such a study is important because of the many diseases related to poor fitness.

Problem Statement

Chronic diseases are the leading cause of morbidity and mortality in the US and most industrialized nations (CDC, 2009; Halpin et al., 2010). Over the past two decades, cardiovascular diseases, diabetes mellitus, obesity, and certain cancers have negatively impacted worldwide health (Halpin et al., 2010). Many chronic diseases are found largely in adults, but research has shown that many of the risk factors start during childhood and adolescence (CDC, 2009).

Researchers still continue to debate the merits of physical fitness assessment (Cale et al., 2007; Rowland, 1995), but there is evidence that supports the assessing, monitoring, and tracking of health-related physical fitness (e.g., CRF) in youths. This is because it is an independent risk factor of cardiovascular disease and metabolic risks that may begin in childhood and be manifested later in life (Andersen et al., 2008). More studies are accumulating, but past studies have focused solely on using normative-referenced standards that are only able to track youths who have poor physical fitness in relation to their peers (Zhu, Mahar, Welk, Going, & Cureton, 2011). Health-related physical fitness studies that have used normative-referenced standards, instead of health-criterion referenced standards, have not provided guidance about how this information is used for screening and intervention purposes (Ovesen, 2006). A limited, but growing, number of health-related physical fitness studies have used assessment tools based on age- and sex-specific criterion-reference standards to determine if youths are fit or unfit based on health criteria. Many of these studies will be discussed in Chapter 2. I am unaware of any published meta-analytic studies in the US that have examined the association of SES, gender, and CRF in adolescent youths. Ceasar et al. (2013) stated that there is still a need for more clarity about associations among sociodemographic variables, such as gender, race/ethnicity, socioeconomic indicators, and CRF. Given the lack of clarity linking gender and SEP with CRF in adolescents, a meta-analysis about available primary studies is needed.

Purpose of the Study

The aim of this meta-analysis (quantitative and observational study) was to summarize/describe the outcome results of multiple studies that determine the association of gender and SEP with CRF in adolescents. The effects of each gender and SEP were also examined.

Research Questions

1. Is gender associated with cardiorespiratory fitness in adolescents?
2. Is socioeconomic position associated with cardiorespiratory fitness in adolescents?

Hypotheses

1a. Null Hypothesis (H_{01}): Gender is not associated with cardiorespiratory fitness.

1b. Alternative Hypothesis (H_{A1}): Gender is associated with cardiorespiratory fitness in adolescents.

2a. Null Hypothesis (H_{02}): Socioeconomic position is associated with cardiorespiratory fitness in adolescents.

2b. Alternative Hypothesis (H_{A2}): Socioeconomic position is associated cardiorespiratory fitness in adolescents.

Information about gender and SEP and their association with CRF were abstracted from the literature databases that met inclusion criteria for this study.

Conceptual Model

The conceptual model used to guide this research project was the physical fitness measures and health outcomes conceptual model (Institute of Medicine, 2012). This model (see Figure 1) was appropriate for this research study because it is concerned with the effects of certain sociodemographic risk factors on health markers. It was based on the premise that health-related physical fitness could result in different health outcomes (e.g., low CRF) based on modifying factors, such as age, gender, and SEP (Institute of Medicine, 2012). The differences that exist can increase the likelihood of poor health outcomes and diseases in some people but not in others (Institute of Medicine, 2012). This model is similar to the socioecological model proposed by McLeroy, Bibeau, Steckler, and Glanz (1988), which shows how multiple factors at multiple levels could affect health outcomes; however, many of the studies included in this meta-analysis emphasized the outcomes of CRF tests based on health risk criteria and examined attribute variables and the roles they play in CRF. For example, the FITNESSGRAM® battery of tests uses metabolic syndrome (cluster of risk factors that could lead to disease) as the health marker (Lobelo et al., 2009).

Figure 1 shows that variables, such as age, gender, and other factors (e.g., socioeconomic factors), could be associated with health markers. If criterion-based assessments like the FITNESSGRAM® are based on the disease risk, then it seems reasonable to conclude that such tests could be used as a proxy for health outcomes. Based on this, the physical fitness measures and health outcomes framework was a viable framework used to guide this investigation. A detailed discussion about the physical fitness measures and health outcomes conceptual model will be provided in Chapter 2.

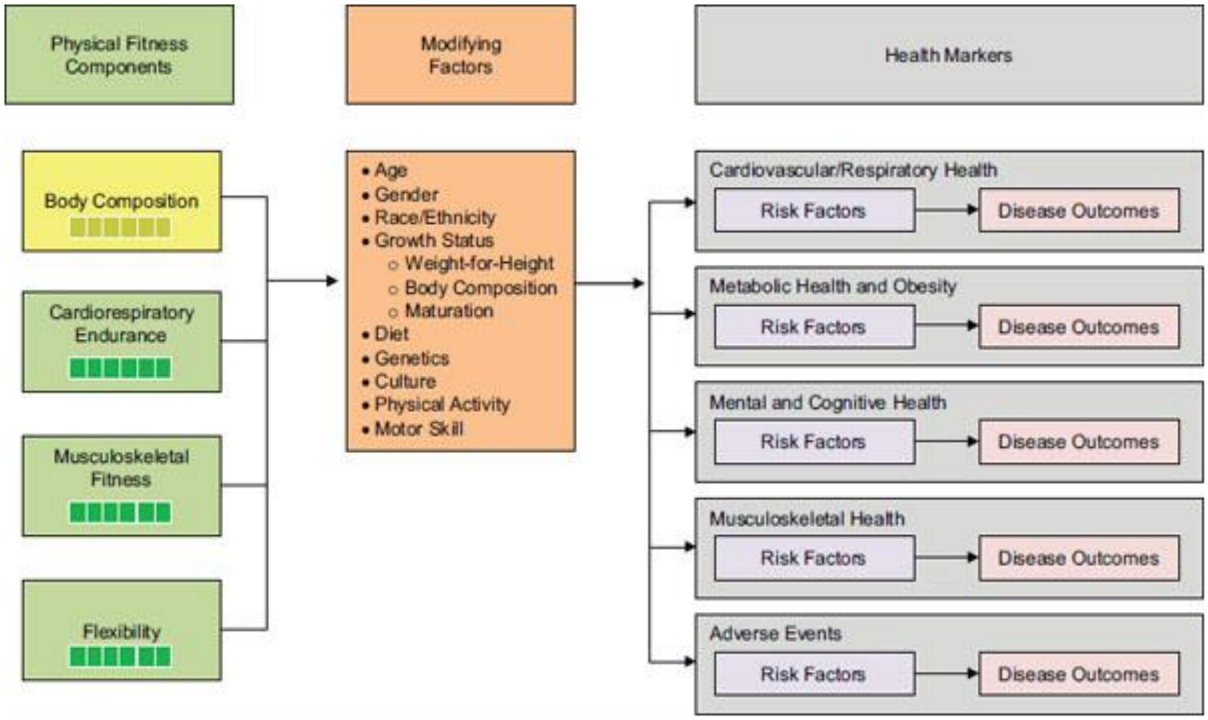

Figure 1. The physical fitness measures and health outcomes conceptual model (Institute of Medicine, 2012). Reprinted with permission (see Appendix A).

Nature of the Study

Low CRF is associated with increased rates of cardiovascular disease and death (Grundy, Barlow, Farrell, Vega, & Haskell, 2012; Lee et al., 2011). Many of the risk factors associated with cardiovascular disease are developed during childhood (Neto et al., 2011) and have the potential to continue into adulthood (Malina, 2001; Ovesen, 2006). Metabolic disease (e.g., metabolic syndrome) is becoming more prevalent in adolescents due to low CRF and inactivity (Neto et al., 2011). Factors, such as gender and SEP, may have roles in the CRF of adolescents which, in turn, may predict poor cardiometabolic health in the future (Ortega, Ruiz, Castillo, & Sjöström, 2008). If these tests truly indicate the probability of disease outcome, a meta-analysis of these studies may aid in future investigations that seek to add to the body of evidence by performing individual studies that determine the associations of these variables with low CRF. This meta-analysis could provide the evidence-based information needed to inform policy in schools about PE, physical activity curriculum, and instruction geared toward different genders in different SEPs and settings.

As previously mentioned, a meta-analysis (i.e., a quantitative observational epidemiologic design) was conducted to answer the aforementioned research questions. Meta-analyses allow for statistically pooling outcomes of all included studies in an attempt to provide an objective, statistical conclusion about the research topic for this investigation (Nordsmann, Kasenda, & Briel, 2012). Results of statistically pooled data could provide evidence that is more powerful than results from a single study to determine roles of the aforementioned variables in the likelihood of low CRF; therefore, a meta-analysis was performed.

The first aim of this study was to determine if gender (independent variable) is associated with CRF (outcome variable). The second aim of this study was to determine if SEP (independent variable) is associated with CRF (outcome variable). For the purposes of this investigation, I am only concerned with the CRF of different genders and SEPs.

The statistical test that will be used to determine the association between variables is the standardized mean difference. Standardized mean difference is an effect size based on means and is used when the outcome of interest is assessed by means of different instruments (Borenstein, Hedges, Higgins, & Rothstein, 2009). More specifically, the sample estimates were used from each study to yield Cohen's *d*. Cohen's *d* is a sample estimate of the standardized mean difference (Borenstein et al., 2009). Cohen's *d* is favorable when making comparisons across varying sample sizes, which was the case with the obtained studies. Cohen's *d* can be interpreted as follows: .30 is considered small, .50 is considered moderate, and above .80 is considered large (Cohen, 1988; Field & Gillett, 2010). Cohen's *d* has been used in previous health-related meta-analyses (Chase & Conn, 2013; Saavedra, Escalante, & Garcia-Hermoso, 2011).

A meta-analysis was chosen for this investigation because it allowed me to pool the results from pre-existing primary studies that were found in electronic databases and libraries; the studies were from different geographical locations, contained different participants, and determined the effect size of these relationships (Pai et al., 2004). Meta-analyses could also identify potential gaps in the literature (Garg, Hackam, & Tonelli, 2008). A cross-sectional study was not feasible due to the difficulty of gaining access to fitness and socioeconomic information from a vulnerable population of youths. The collection of data would have been resource-intensive because of the amount of time needed by school officials to collect information. In an attempt to generalize the results to different populations, settings, and contexts, I would have needed to collect information from different populations, settings, and contexts. Therefore, I chose to perform a meta-analysis to investigate the association of gender and SEP with CRF.

Definitions

For readers to be clear about the terminology used in this research study, the following definition of terms is provided:

Aerobic capacity (cardiorespiratory fitness or *aerobic fitness):* “The body’s capacity to transport and use oxygen during maximal exertion involving dynamic contraction of large muscle groups, such as during running and cycling” (Lindsay et al., 2013, p. 2).

Body composition: “Health-related fitness component that applies to body weight and relative amounts of muscle, fat, bone, and other vital tissues of the body” (Lindsay et al., 2013, p. 2). Body mass index (BMI) was used as a proxy measure for body composition. BMI was also used in the calculation for VO_2 max and is age and gender specific.

Healthy fitness zone (HFZ): HFZ is used to indicate whether an individual is fit versus unfit. It is based on the criterion-based standard that has been established to indicate a level of fitness that offers some protection against diseases that result from an inactive lifestyle (Meredith & Welk, 2004). For this study, boys who had a VO_2 max of 42 ml/kg/min or higher and girls who had a VO_2 max of 35 ml/kg/min or higher were categorized in the HFZ. Participants who were below the VO_2 max for boys and girls were considered unfit and categorized as not achieving the HFZ status (Meredith & Welk, 2004).

Needs improvement: A level of fitness that should be improved upon by people who take the FITNESSGRAM® (Meredith & Welk, 2004).

Physical activity: “Any body movement that enhances and increases energy expenditure about basal levels” (Lindsay et al., 2013, p. 2).

Physical fitness: "Capacity to perform physical activity based on various physiological parameters. One can be physically active and not physically fit, or have some increased measures of fitness and not be active" (Lindsay et al., 2013, p. 2). The 1-mile run was the proxy measure of physical fitness.

Poverty: A set of money income thresholds that vary by family size and composition to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual in it was considered to be in poverty. For this study, students who received or were eligible for free or reduce-priced lunches were the economic-based construct to determine poverty level (i.e., high versus low). Families with an income at or below 130% of the poverty level are eligible for free lunch, but families between 130% and 185% of the poverty level are eligible for reduced-price meals (U.S. Census Bureau, 2014).

Race/Ethnicity: Race and ethnicity are categories developed by the U.S. Office of Management and Budget (Humes, Jones, & Ramirez, 2011). Individuals are classified by ethnicity first (e.g., Hispanic versus non-Hispanic) and then by race (e.g., African American/Black, Asian, American Indian/Alaska Native, Native Hawaiian or Other Pacific Islander, and Caucasian/White; Humes et al., 2011). For the purposes of comparison, race was categorized as White versus non-White, and ethnicity was categorized as Hispanic versus non-Hispanic.

Socioeconomic position (SEP): SEP is defined as "social or economic factors that influence what positions individuals or groups hold within the structure of society" (Galobardes, Shaw, Lawlor, Lynch, & Smith, 2006, p. 7). SEP includes indicators such as education, occupation, and income; SEP is also a combined measure (American Psychological Association, 2014).

Search Strategy for Applicable Studies

An electronic and manual search on databases and in libraries was conducted to find studies and relevant articles that focused on CRF and adolescents. Inclusion and exclusion criteria were established to limit the results to only studies, articles, and reports that provided summaries of statistical outcomes that contributed to the overall pooled summary of the meta-analysis. Chapter 3 contains more information about the search strategy used, inclusion criteria, and exclusion criteria.

Study Characteristics Included in the Meta-Analysis

This meta-analysis was limited to observational (cross-sectional) studies. These studies that were used to research diseases (and other health outcomes) included cohort studies, cross-sectional studies, and case-control studies (Von Elm et al., 2007). The research questions in this investigation are best answered by using cross-sectional studies. With this in mind, it was appropriate to use a checklist of items that should be included in cross-sectional studies. For the purposes of this investigation, each cross-sectional study was examined for quality by using the Strengthening the Reporting Observational Studies in Epidemiology (STROBE) Statement (Von Elm et al., 2007). Additionally, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was used as a guide of what items were included in this meta-analysis (Moher, Liberati, Tetzlaff, & Altman, 2009). The flow of the review and the items included in this meta-analysis are discussed in detail in Chapter 3.

Statistical Procedures

The meta-analysis was conducted with the Comprehensive Meta-Analysis (CMA) software developed by Biostat Incorporated (Comprehensive Meta-Analysis, Version 2). The CMA software provided the following procedures needed for this meta-analysis: effect size measures, multiple design within the same analysis, fixed and/or random effects models, inverse variance models, subgroup analysis, sensitivity analysis, moderation analysis, and statistical tools to detect publication bias (e.g., funnel plots).

The primary effect size used to detect the association between the study variables in this investigation is Cohen's *d*. Cohen's *d* describes the likelihood of an outcome change with a one-unit change in a predictor variable or variables (Katz, 2011). Cohen's *d* was determined to be the best for a variety of reasons. First, Cohen's *d* can easily be calculated when the mean, standard deviation, and sample size are available, which increased the number of studies that could be included in the final meta-analysis. Additionally, McGrath and Meyer (2006) noted that Cohen's *d* is favorable when making comparisons across varying sample sizes, which was the case with the obtained studies. Cohen's *d* can be interpreted as follows: .30 is considered small, .50 is considered moderate, and above .80 is considered large (Cohen, 1988; Field & Gillett, 2010); they are commonly used in meta-analysis as summary estimates.

A random effects model will be used in this meta-analysis because the studies may only be a random sample of all possible studies for the stated research questions, the data may be heterogeneous, and the true effect may vary because of the differences between samples and studies (Littell, Corcoran, & Pillai, 2008). Reports have shown that random effects models are appropriate to use because in the absence of heterogeneity, similar results will be produced with fixed effects models (Pai et al., 2004). I^2 and Q tests were used to statistically assess heterogeneity between studies. There are similarities and differences between fixed and random effects models. The estimated calculation with both are similar in magnitude; however, the confidence intervals produced by random effects model tends to be larger to account for heterogeneity across individual effect sizes (Borenstein et al., 2009).

Moderation analyses were performed among sample size, gender, SEPs, country of origin, and potential outliers to evaluate the effect size variations (assuming there are variations). Publication bias was assessed using Rosenthal's failsafe *N* (Thorton & Lee, 2000). Duval and Tweedie's trim and fill method was used to adjust for publication bias (Borenstein, 2005), and funnel plots were used to visually inspect for biases.

Assumptions

For the purposes of this research study, I made several assumptions that pertain to CRF testing. I assumed that all youths were capable of changing their CRF by engaging in physical activity and that the assessment and use of CRF data could lead to changes in school health policy and PE curriculum and instruction that will promote cardiovascular health through increased physical activity. I also assumed that assessing CRF, making students and parents aware of the status of their children, and giving youths the opportunity to become knowledgeable and skilled at creating their own fitness programs will encourage students to engage in more moderate-to-vigorous physical activity. This, in turn, may positively affect health-related physical fitness and health. I also assumed that all field-test assessments were conducted in a standardized way and that the test results gathered in the database were entered correctly. CRF is a physiological state that may also be explained by genetic factors (Gaskill et al., 2001; Pérusse et al., 2001), but physical activity is a behavior that can be modified and can affect CRF (McKenzie, 2007; McKenzie & Lounsbery, 2013); therefore, I assumed that CRF can be improved by engaging in physical activity.

For the purposes of this meta-analytic study, it is also assumed that the primary studies used in this meta-analysis met scientific rigor and that measures were taken to ensure quality before publishing. This is the rationale for the peer-reviewed research. The quality of this meta-analysis was dependent on the quality of the research that was used. As such, this is a major limitation when performing meta-analyses.

Scope and Delimitations

This research study filled a gap in the literature by determining whether (a) gender is associated with CRF status in adolescents and whether (b) SEP is associated with CRF in adolescents. This meta-analysis did not examine adult studies and only examined these associations in adolescent boys and girls between 11 and 18 years of age, which is the age range that the World Health Organization (WHO) classifies youths as adolescents (WHO, 2015). This meta-analytic study did not include experimental or quasi-experimental studies because the research question can best be answered by using a compilation of observational studies. This research endeavor is limited to investigating the association of gender and SEP with CRF. Finally, due to the criteria that were established as boundaries for this meta-analysis, the generalizability of findings may only apply to the populations and settings used in this meta-analysis.

Limitations

Study limitations are the characteristics of study designs or methodologies that may influence the study results but that researchers cannot control (Arnold, Gansneder, & Perrin, 2005). With this in mind, some shortcomings must be considered when using a meta-analysis. First, this analysis was based on secondary data that were retrieved from electronic databases, libraries, and other locales and are not primary data I collected. As such, the outcome data retrieved from each study were only as reliable and trustworthy as the test instruments and statistical analyses used. The STROBE checklist was used to assess the quality of all observational studies.

Additionally, the use of aggregate data (instead of individual participant data) needs to be considered. The information collected was limited to aggregate data taken from the summary results of each peer-reviewed article. I did not collect individual-level data (i.e., raw data), which must be noted because the statistical methods that were used must account for the clustering effect (Abo-Zaid et al., 2013). All studies were assessed to account for clustering and were excluded if it was not accounted for in the article.

A third limitation was the use of observational studies. Some researchers have suggested that observational studies (like cross-sectional studies) are not randomized, controlled trial studies, so they impose threats to validity, such as confounding, biases, and chance (lack of randomization; Shrier et al., 2007). Most notably, observational studies do not allow for causal inference (Carlson & Morrison, 2009; Mann & Wood, 2012). This is because the exposure and outcome are measured concurrently (Carlson & Morrison, 2009). As such, it is difficult to ascertain the temporal relationship between exposure and outcome. It was also beyond the scope of this investigation to assess changes in CRF or to assess interventions. Therefore, given the research question, it was not appropriate to use studies that aimed to assess changes in CRF over time or assess the effectiveness of interventions focused on changes in CRF. Even with these weaknesses, observational studies have a place in meta-analytic reviews (Shrier et al., 2007) because some health outcomes can only be studied observationally (Walker, Hernandez, & Kattan, 2008). Observational studies, while limited in terms of experimental control, were still the best fit with the research questions for this investigation.

There was a limit to considering all of the potential confounders that could influence the results of the study. My knowledge falls short when considering all of the potential variables that were unaccounted for that could bias the results of this study (even with randomization). The conceptual framework (Institute of Medicine, 2013) that was used to guide this meta-analytic study lists several potential correlates, but it is beyond my knowledge and is unfeasible to consider every unknown variable that may influence CRF; however, based on the variables presented in the conceptual model used to guide this research, I am interested in assessing the association of gender and SEP with CRF in adolescents. There was also a limit of only being able to extract data that were reported in the articles. Therefore, certain demographic or sample factors could not be parceled out. Finally, there was a limit in knowing if all primary studies that pertain to the research questions would be acquired. Statistical measures were used to assess and adjust for publication biases.

Significance

Prior research has suggested that school-based interventions (e.g., PE), could decrease the likelihood of developing chronic diseases commonly associated with physical inactivity and low physical fitness (Ortega, Ruiz, Castillo, & Sjöström, 2008; Ruiz et al., 2009). This study could potentially advance knowledge in the field of public health, health promotion, and PE by establishing the potential need for more gender-specific physical activity programs to promote CRF in disenfranchised and vulnerable populations. This meta-analytic study could also promote the need for additional research about how gender and SEP influence low CRF. The social change implications of this study could lead to increased physical activity, enhanced CRF and cardiovascular health, and decreased health costs associated with physical inactivity and low CRF in adolescents as they transition into adulthood (American Diabetic Association, 2013).

Summary

Studies have shown that physical activity and CRF have declined among youths. Furthermore, subgroup analyses have revealed disparities among those who are physically active and physically fit versus those who are not. Low levels of physical activity and CRF may continue into adulthood. Chronic conditions, such as cardiovascular disease and diabetes mellitus (Type 2) may be associated with a decline in physical activity and physical fitness. Markers of the biogenesis of these conditions have been found in youths (Steinberger & Daniels, 2003). Much of the literature has highlighted the measurement and promotion of physical activity without assessing CRF, which is a more powerful marker of health. Research has shown a decline in physical activity and certain health-related physical fitness measures in adolescents that may negatively affect CRF and cardiovascular health (Lee et al., 2011).

The literature is inconclusive about whether gender and SEP (and other known factors) play a role in cardiovascular fitness and cardio-metabolic health. Based on the conceptual model used to guide this investigation, these factors could be linked; however, without assessing the overall magnitude and direction of the association among gender, SEP, and CRF in the adolescent population, it would be difficult to make an informed decision based on objective evidence. A statistical compilation of study outcomes concerning this topic may provide the information needed to make informed decisions concerning this topic. With this in mind, in this meta-analytic study, I investigated the pooled estimate concerning the association of gender and SEP with CRF in adolescents.

The positive social change implication of this meta-analysis may provide evidence-based knowledge to physical educators and health educators who are considering changes in school health promotion policies about the implementation of health promotion interventions geared toward different gender and socioeconomic groups. Long-term results would include increased physical activity, decreased risk factors in clustered cardiovascular disease, and lowered all-cause and cardiovascular disease mortality as adolescents continue into adulthood.

In Chapter 2, I will discuss the state of physical activity and physical fitness (with specific emphasis on cardiovascular fitness) as well as some of the methodological weaknesses that exist with the current literature. Finally, I will review relevant literature concerning the association of gender and CRF and SEP and CRF.

Chapter 2: Literature Review

Introduction

Physical inactivity is a known risk factor for chronic diseases associated with premature death. PE teachers and others who promote health have long known the importance of physical activity and its effect on children's health. It has also been apparent that physical activity levels tend to differ depending on gender and socioeconomics. However, limited studies have examined the association among gender, SES, and CRF among youths (Ceasar et al., 2013). The purpose of this review is to examine the research studies that have (a) determined if gender is associated with CRF in adolescents and (b) determined if SEP is associated with CRF in adolescents. CRF has been noted as a stronger marker of health in adolescents (Ortega, Ruiz, Castillo, & Sjöström, 2008), and physical activity has been shown as a modifiable way to achieve CRF (Owens & Gutin, 2014); therefore, it is important to discuss the impact of physical inactivity and CRF on cardiovascular and cardiometabolic health.

Physical inactivity continues to be a growing problem in the US (Go et al., 2013). Nationwide, students are not engaging in the recommended amount of physical activity (Go et al., 2013). Despite evidence that adolescents should be performing at least 60 minutes of daily physical activity, many adolescents are not meeting this recommended guideline (Eaton et al., 2012). Furthermore, physical inactivity during adolescence is related to certain metabolic and cardiovascular diseases that tend to track into adulthood (Fernandes & Zanesco, 2010; Iannotti & Wang, 2013). Moreover, chronic conditions associated with physical inactivity have large economic and health costs (CDC, 2012;

Finkelstein, Trogdon, Cohen, & Dietz, 2009). Likewise, physical fitness levels have been associated with the health of children and adolescents (Hurtig-Wennlöff, Ruiz, Harro, & Sjöström, 2007; Ortega, Ruiz, Castillo, & Sjöström, 2008). One literature review has suggested that adolescents who are socioeconomically disadvantaged were more likely to have physical inactivity compared to high SES adolescents (Hanson & Chen, 2007).

Out of 34 studies reviewed by Hanson and Chen (2007), 20 showed a positive correlation between SES and physical activity, whereby those in higher social classes were found to be more active than were those from lower social classes. Many low SES teens tended to live in environments that were not conducive to physical activity (e.g., unsafe environments or lack of green space to exercise), or they would have to work to earn spending money or to help with family finances (Hanson & Chen, 2007).

Other studies have shown that adolescents with higher SES may be more active because they are able to afford the required financial outlay to purchase sports equipment and club memberships (Stalsberg & Pedersen, 2010). Hanson and Chen (2007) also noted that some findings showed a negative association and null findings when subgroup analyses were performed. Plausible reasons for these differences include variations in the SES measure used, the sample size and makeup of the sample, and the methodology. Nevertheless, Hanson and Chen found that social status, age, and gender were stronger predictors of physical activity than were financial resources. Interestingly, they found studies that considered race/ethnicity as a moderator between SES and physical activity (Hanson & Chen, 2007).

Two European (Guedes, Neto, Lopes, & Silva, 2012; Jiménez-Pavón, Ortega, Ruiz, Chillón, et al., 2010) and two U.S. studies (Bohr, Brown, Laurson, Smith, & Bass, 2013; Fahlman, Hall, & Lock, 2006) showed links between SES and physical fitness. Studies have shown gender, age, and SES differences on several health-related physical fitness components (including CRF; Bohr et al., 2013; Fahlman et al., 2006; Guedes et al., 2012; Jiménez-Pavón, Ortega, Ruiz, España Romero, et al., 2010). Based on the limited amount of published literature about the association between SES and health-related physical fitness (with a specific emphasis on CRF), this meta-analytic investigation could encourage more research studies to investigate this phenomenon. Using the existing literature, others can statistically pool the outcomes of studies that examine associations between gender, SEP, and the likelihood of low CRF.

A related issue is the interaction between race/ethnicity and SEP. According to one report, "[d]emonstrated racial/ethnic and gender 'effects' may be intricately related to socioeconomic factors, because race/ethnicity interacts with and is confounded by social class or socioeconomic status" (Committee on Pediatric Research, 2000, p. 1350). Furthermore, Fahlman et al. (2006) found that race/ethnicity was a significant predictor of the 1-mile run, even after adjusting for SES. However, only high school females were used in this study, and eligibility for free and reduced lunch was the sole indicator for SEP.

Furthermore, Pate, Wang, Dowda, Farrell, and O'Neill (2006) performed a cross-sectional study that assessed the CRF level of a nationally representative sample of 12- to 19-year-old students in the US and found no significant differences between non-

Hispanic Whites, non-Hispanic Blacks, or Mexican American males (*p* = .27) or females (*p* =.15). However, Pate et al. (2006) did not measure SES or the interaction of race/ethnicity with SES. Many studies have shown that race/ethnicity is not predictive of long-term health when adjusting for SES (Hayward, Crimmins, Miles, & Yang, 2000; Kington & Smith, 1997).

Myers (2009) proposed that race/ethnicity, social class, and the environment interact and trigger mechanisms that lead to chronic diseases. If race and ethnicity do not predict health outcomes or are too difficult to parcel out, then it seems appropriate to study the association of SEP and CRF. Therefore, in this study, I seek to determine the association between gender, SEP, and the outcome of CRF in adolescents by statistically pooling the summary results of the limited studies that meet inclusion criteria. Schools could potentially benefit from studies that examine these associations because they could serve as a leverage point for affecting change in health policy, PE curriculum, and instruction.

School-based interventions have received much attention for combating health-compromising behaviors and increasing health-promoting behaviors (Naylor & McKay, 2008). Dobbins, Husson, DeCorby, and LaRocca (2013) and Sun et al. (2013) have touted school-based physical activity interventions as an effective way to promote physical activity; however, the magnitude of intervention effects are small, and the strategies used to intervene remain controversial (Dobbins et al., 2013; Kriemler et al., 2011). Teens who reside in socioeconomically disadvantaged neighborhoods may not have access to physical spaces, facilities, or instruction that could afford them the opportunity to increase physical activity and fitness levels (Chillón, Ortega, Ferrando, & Casajus, 2011). For this reason, schools are promising places to use computer-based technology in order to increase physical activity (Thomas, 2008).

Schools serve as a promising setting for increasing physical activity because large segments of youths can be reached during the day (Institute of Medicine, 2013; Kohl & Cook, 2013). One way of reaching these students during the course of a normal day is through PE. However, the No Child Left Behind Law (Siedentop, 2009) may be contributing to lowered CRF in adolescents due to less focus on physical activity and fitness and more focus on core subjects (Siedentop, 2009). This decrement in physical activity time may have negative ethical and educational consequences (Trost & van der Mars, 2010).

Trost and van der Mars (2010) argued that decreasing physical activity time in schools may contribute to childhood obesity and deny students the opportunity to develop the skills and knowledge necessary to pursue an active lifestyle. Despite these reasons, many schools continue to reduce PE and time for physical activity to increase time spent in core classes even though the evidence suggests that academic performance is unaffected or enhanced by the amount of time that students spend in PE (Trost & van der Mars, 2010).

Trost and van der Mars cited studies that showed a positive correlation between physical activity and improved academic performance. Recent reviews have also suggested a significant longitudinal relationship between physical activity and academic performance. Singh, Uijtdewilligen, Twisk, van Mechelen, and Chinapaw (2012) identified 14 observational studies and four intervention studies and found two high quality studies that supported this relationship. Moreover, Howie and Pate (2012) reviewed 125 observational and experimental studies to detect a relationship between physical activity and academic achievement and found that physical activity had an overall positive effect on constructs of academic achievement.

Similarly, Haapala (2013) performed a literature review that listed several cross-sectional studies showing a link between cardiovascular fitness and academic achievement/performance in youths (Haapala, 2013). If a correlation exists between physical activity and academic performance and if physical activity is a modifiable behavior that is associated with increased fitness, then physical educators should use the data retrieved from physical fitness tests to track trends in the status of physical fitness; this may serve to further promote the usefulness of PE in promoting physical activity and physical fitness in schools.

A primary interest to public health professionals and physical educators is how increased health-related physical fitness (e.g., CRF) impacts population health (Kokkinos & Myers, 2010). An estimated 400,000 deaths occur each year as a result of physical inactivity (Mokdad, Marks, Stroup, & Gerberding, 2004). Surprisingly, relatively few studies have investigated the association of gender and SEP and the effects these may have on CRF in youths (Bohr et al., 2013; Gordon-Larsen, Adair, Nelson, & Popkin, 2004; Matton et al., 2006; Pate, Trost, Dowda, Ott, & Ward, 1999; Pate et al., 2006). To the extent that physical activity and health-related physical fitness (e.g., CRF) are positively associated (Martínez-Vizcaíno & Sánchez-López, 2008), and to the extent that physical fitness is a powerful marker of health (Ortega, Ruiz, Castillo, & Sjöström, 2008), it is plausible that understanding these relationships could be used to further inform health policy, curriculum, and instruction in schools.

Using data to inform practice and guide decisions about student performance and achievement is the primary means by which educators are held accountable for student success (Marsh, Pane, & Hamilton, 2006). Data-driven decision-making has a historical basis in education and has been used to drive instruction (Popham, 1987; Popham, Cruse, Ranking, Dandifer, & Williams, 1985). Using data to inform school health promotion policies is important for physical educators and others who promote health; however, physical educators may use health-related fitness data to inform interventions (Ernst, Corbin, Beighle, & Pangrazi, 2006). This is especially true with regard to patterns and trends in health-related fitness (Welk et al., 2010). Quantifying the overall impact of sociodemographic variables, such as gender and SEP, may provide evidence for or against changes in health policy, curriculum, and instruction. Therefore, the two aims of this meta-analysis are (a) to assess if gender is associated with CRF in adolescents and (b) to determine if SEP is associated with CRF in adolescents.

This chapter presents the theoretical framework that serves as a backdrop to this investigation. Epidemiological evidence is presented to provide readers with information about the deleterious effects of physical inactivity and low CRF, followed by a discussion of the literature related to gender, SEP, and each variable’s influence on CRF outcomes. Finally, I summarize the major themes of the literature and propose how this research study fills a gap in the literature.

Theoretical Framework

The theoretical framework used to guide this research project was the physical fitness measures and health outcomes conceptual model (Institute of Medicine, 2012). This model is appropriate for this research study because I am concerned with the effects of the certain sociodemographic risk factors on health markers, such as low CRF. Some studies in the public health literature have implicitly used this conceptual model to analyze outcomes (Pate et al., 2006; Wang et al., 2010; Welk et al., 2010). These researchers do not explicitly label their studies as being guided by this conceptual model, but it is inherent in their descriptive analysis of the fitness levels of different sociodemographic variables over time and in different locations. For example, Carnethon, Gulati, and Greenland (2005) performed a cross-sectional study to assess (a) the prevalence of low CRF of adolescents and adults and (b) the association of low CRF to cardiovascular risk factors. Carnethon et al. (2005) stratified their analysis by age (adolescent/adults) and sex (male/female) to assess the prevalence of low CRF and the association of low CRF with cardiovascular risk factors.

Pate et al. (2006) also performed their cross-sectional study to examine CRF levels of a nationally representative sample of U.S. adolescents based on several sociodemographic variables (age, sex, race/ethnicity, and physical activity). Furthermore, Wang et al. (2010) performed this same analysis on 20- to 49-year-old adults in the US. It is assumed that the stratification into homogeneous groups was performed because these researchers wanted to rule out the moderating effects of age and sex. With this in mind, the physical fitness measures and health outcomes conceptual model is an appropriate model to guide this research study. The next section will cover the epidemiology of physical inactivity and low CRF and the deleterious effects of not reversing each of these factors in youths.

Epidemiology of Physical Inactivity and Low CRF

Over the past 50 years, the epidemiological and experimental evidence has suggested that humans have become less active and more susceptible to sedentary lifestyle diseases (Archer & Blair, 2011). Physical inactivity is an established independent risk factor for many chronic diseases (Lee et al., 2012). Cardiovascular disease, hypertension, obesity, diabetes mellitus (Type 2), metabolic syndrome, and certain cancers have been associated with physical inactivity (Anzuini, Battistella, & Izzotti, 2011; Durstine, Gordon, Wang, & Luo, 2013; Kokkinos, Sherrif, & Kheirbek, 2011; Neto et al., 2011; Qin, Knol, Corpeleijn, & Stolk, 2010; Reddigan, Ardern, Riddell, & Kuk, 2011). Reports have shown that chronic health conditions have increased from 1.8% to more than 7.0% (CDC, 2009). The worldwide economic costs associated with chronic diseases has been estimated into trillions of U.S. dollars per year (Bloom et al., 2011).

Chronic diseases tend to be associated with older populations (CDC, 2009; Ward & Schiller, 2013), but they are becoming a growing trend among adolescents (CDC, 2009; May, Kuklina, & Yoon, 2012). In a cross-sectional study, May et al. (2012) found that nearly 15% of all adolescent participants surveyed were prehypertensive or hypertensive (n = 3,383, 52% male, 48% female, and included non-Hispanic Blacks, Whites, and Hispanics). May et al. also reported that 22% of the adolescents surveyed had increased levels of low lipoprotein cholesterol, and 15% of them were prediabetic or diabetic. The largest prevalence rate was found in those who were prediabetic or diabetic (May et al., 2012). Prediabetes and diabetes was more prevalent in overweight and obese adolescents than they were in adolescents of normal weight (as measured by BMI; May et al., 2012).

Other studies have shown that lifestyle risk factors contribute to chronic disease and that these factors tend to cluster during adolescence (Dumith, Muniz, Tassitano, Hallal, & Menezes, 2012; Plotnikoff et al., 2009). For example, Plotnikoff et al. (2009) conducted a survey to assess the "prevalence, clustering, age trends, and gender differences of chronic-disease-related risk factors in a large sample (n = 4,932) of Canadian adolescents" (Grades 7 through 10; p. 606). Some important findings included those in which physical activity tended to decrease as adolescents increased in age (boys: $F = 28.79$, $p < .001$; girls: $F = 81.90$, $p < .001$) and those in which risk factors, such as cigarette smoking and fat intake, were negatively correlated with physical activity (boys: $r = -.07$, $p < .01$; girls: $r = -.08$, $p < .001$). When this information is combined with evidence that physical inactivity is an independent risk factor associated with chronic disease (Allison, Adlaf, Dwyer, Lysy, & Irving, 2007; Durstine et al., 2013), it becomes evident that adolescents need to engage in more physical activity to decrease the likelihood of chronic disease.

In the US, nearly 14% of teens in high school did not participate in at least 60 minutes of moderate-to-vigorous physical activity per day (Eaton et al., 2012). This was particularly the case for Hispanic and non-Hispanic Black females (26.7% and 21.3%)

and males (12.3% and 10.7%) when compared with non-Hispanic White males and females (8.5% and 13.7%; Eaton et al., 2012). These data show that physical activity tends to decrease with age (Eaton et al., 2012). Similarly, non-Hispanic White males and females (62.1% and 42.6%) tended to engage in more moderate-to-vigorous physical activity on 5 or more days when compared to Hispanic and non-Hispanic Black males and females (57.1% and 31.9%; Eaton et al., 2012). To the extent that physical inactivity and certain health-related fitness states track into adulthood (Gordon-Larsen et al., 2004; Pate, Heath, Dowda, & Trost, 1996), additional research is needed that investigates the contribution of race/ethnicity when assessing the association of gender and SEP with the likelihood of low cardiovascular fitness because it may be an effect modifier in the association among gender, low cardiorespiratory health, SEP position, and low CRF.

Physical activity is a modifiable behavior that can be a point of emphasis for changes in health and fitness status. Strong et al. (2005) performed a systematic review to study how physical activity affected health and behavior outcomes and concluded that physical activity has a low-to-moderate positive correlation with cardiovascular fitness (CRF). Strong et al. (2005) did not perform a meta-analysis to produce more objective evidence for their statement, but their subjective conclusions have led to investigations that focus on promoting physical activity and decreasing physical inactivity (Bauman et al., 2012). However, very little literature has focused on evidence-based knowledge concerning the correlates and determinants of CRF in youths (Carnethon et al., 2005; Filho, da Silva Lopes, Bozza, Rech, & de Campos, 2014). With this in mind, the purpose of this literature review was to search for and locate studies that focus the association of gender and SEP with CRF in adolescents. , After collecting the information, I statistically pooled the results to generate a summary effect size (Cohen's *d*).

Literature Search

The literature search for this investigation began in 2009 and ended in July of 2014. The articles reviewed for this study were identified using the following databases: HighWire, CINAHL & MEDLINE Simultaneous Search, PubMed, Nursing & Allied Health Source, Google Scholar, and ScienceDirect. Keywords used for the search included *physical fitness* or *fitness* or *cardiorespiratory fitness* or *aerobic capacity* and *gender* or *sex*, and *socioeconomic status* or *socioeconomic position* or *poverty* or *social status* and *adolescents* and *teenagers* and *correlates* or *determinants* and *association*. Only databases available through Walden University were utilized. Hard copy forms of studies were also located at local university libraries located about 50 minutes away. Some limited studies examined the association of gender, SEP, and CRF in adolescents, which supports Ceasar et al.'s (2013) conclusion that "the degree of association of other socio-demographic factors on CRF [cardiorespiratory fitness]….is not well described" (p. 287). The next section describes the literature that met inclusion for this meta-analysis.

Related Literature Review

Filho et al. (2014) performed a cross-sectional study in southern Brazil by analyzing socioeconomic, lifestyle, and behavioral indicators that could be associated with cardiorespiratory (and muscular) fitness among adolescent boys and girls (n = 1,555, 737 boys, 818 girls; age: M = 14.26 years, SD = 1.60 years). A stratified analysis was performed to determine if gender differences existed in these correlates, and CRF (VO_2

max) was measured using the 20-meter shuttle run test. Age- and sex-specific *z* scores were used to estimate CRF based on the sample itself and were used to dichotomize outcomes. Students who received negative scores were labeled as having low CRF, and those who had positive scores were categorized as having high CRF.

Correlates of income, employment status, and head of household education were measured. Income was measured using a questionnaire by the Brazilian Association of Research Companies and was dichotomized into those who were in the best and worst conditions. Head of household education was measured based on the length of years of schooling (≤ 8 years, 9–11 years, and ≥ 12 years). Employment status was measured by asking if the students were employed or unemployed. Environmental variables (e.g., number of PE classes per week) and behavioral variables (e.g., time spent engaged in physical activity in PE class and in television and computer time) were also measured.

Logistic regression analysis for boys found that they were more likely to have low CRF according to the following: head of household schooling, $OR = 1.73$ and 95% CI [1.08–2.77, $p < .05$]; involvement in organized physical activity, $OR = 2.24$ and 95% CI [1.62–3.11, $p < .01$]; physical activity level, $OR = 1.61$ and 95% CI [1.11–2.34, $p < .05$]; and hours per week using computers/games on weekdays only or every day for 3 or more hours ($p < .05$). SES, as measured by the construct used in this study, was associated with low CRF but not after adjusting for other covariates. However, parental education was correlated, so those with higher education status had lower CRF. Girls were more likely to have low CRF according to the following: engagement in less than 30 minutes of PE class, $OR = 1.54$ and 95% CI [1.04–2.27, $p < .05$] and engagement in watching television for 3 or more hours, *OR* = 1.62 to 2.04, $p < .05$ and $p < .01$). Neither SES nor head of household schooling was associated with CRF after adjusting for all covariates. The limitations of this study were the indirect use of field tests to measure CRF, use of self-reported measures to identify behavioral factors, and lack of generalization about those who attend schools in different geographic locations or private schools. Ethnicity was also not considered in this investigation, and the cross-sectional nature of this study only showed relationships, and not the direction of causality.

Guedes, Neto, Lopes, and Silva (2012) conducted a study that was also used to evaluate correlates of health-related physical fitness in Brazilian students. They sampled 1,457 girls and 1,392 boys, ages 6 to 18 years, who attended public and private schools. Information about age, socioeconomic level, parent education, consumption of school meals, and other indicators were collected. The same instrument that was used to determine SES in Filho et al.'s study was used in Guedes et al.'s study. Students were classified as high level or low level, based on the resulting scores on the survey. Health-related physical fitness was measured using the FITNESSGRAM® battery, and CRF was measured using the Progressive Aerobic Cardiovascular Endurance Run (PACER) test. FITNESSGRAM® cut-off scores were used as criterion-based standards for health.

Data were stratified by gender, age, SES, parental education level, paid work, and other variables. Logistic regression analysis revealed that participants were more likely to achieve the HFZ status according to the following: boy participants, *OR* = 1.70 and 95% CI [1.36– 2.07]; participants from 10 to 14 years of age, *OR* = 2.08 and 95% CI [1.75–2.43]; lower socioeconomic classes, *OR* = 2.18 and 95% CI [1.84–2.54]; lower parental education, *OR* = 1.81 and 95% CI [1.52–2.54]; and students who did not work, *OR* = 1.74 and 95% CI [1.43–2.06]. These findings are similar to Filho et al.'s study because they found an inverse relationship between parental education and CRF. Limitations included the cross-sectional nature of the study, which does not present the direction of causality, the use of self-reported surveys to acquire information about socio-demographic, and behavioral variables.

Petroski, Silva, de Lima e Silva, and Pelegrini (2012) performed a cross-sectional study in Brazil to examine the association between health-related physical fitness components and sociodemographic indicators in 15- to 19-year-old students (*N* = 605). The authors hypothesized that certain sociodemographic indicators are associated with health-related components of physical fitness in Brazilian youths. Similar to the aforementioned studies, these investigators used scores from the questionnaire created by the Brazilian Association of Market Research Companies, which categorized students into five economic classes based on spending power. Unlike the other studies, three classes were used (i.e., high, medium, and low) to indicate the SES of each participant. The researchers were unclear about the specific battery of tests that were used to measure fitness, but the bench test was used to measure aerobic (cardiorespiratory) fitness. Outcome was collapsed down to healthy or unhealthy.

Crude and adjusted logistic regressions were performed to determine the association between the exposure variable, covariates, and the CRF (categorically defined as healthy or unhealthy). Distributional results show that nearly 31% of the participants were considered unhealthy with regards to aerobic fitness, 95% CI [26.8–34.2]. Most participants were older (36.1%) males (49.3%) in the 12th grade (35.3%) from the upper class. All were significant with a 95% confidence interval. Crude logistical analysis showed that males were nearly four times more likely to be unhealthy than were females, *OR* = 3.88, 95% CI [2.69–.59], $p < 0.05$. Likewise, older participants were 1.50 times more likely to be unhealthy than were younger students, 95% CI [1.05–.15]. The crude analysis did not indicate any association between CRF and SES. The adjusted analysis showed similar results for gender and age. Limitations of this study were the sample population, which came from state-funded secondary schools and the cross-sectional nature of the study.

Minatto, Petroski, and Santos Silva (2012) examined the prevalence of low health-related physical fitness with sociodemographic indicators in 277 Brazilian youths who were 10 to 17 years old (145 boys and 132 girls). The FITNESSGRAM® test battery was used to assess health-related physical fitness, and the 20-meter PACER test was used to assess CRF. The sociodemographic variables that were assessed were age, sex, SES, and area of residence. Similar to aforementioned studies, the same instrument was used to assess SES, and categories of low status and high status were used. Additionally, sexual maturation was assessed using the Tanner pubic hair development scale. Distribution analysis revealed that a higher proportion of boys between 13–17 years old (51.7%) lived in rural areas (69.3%) and belonged to low SES (56.5%). However, most girls of the same age (56.8%) lived in rural areas (67.2%) and belonged to high SES (55.1%).

Results revealed that boys had higher mean VO_2 max values for CRF (44.23 versus 40.56, $p < 0.000$) than did females, but boys and girls were similar with regards to the proportion of boys and girls who had low CRF. The adjusted binary logistic analysis found that girls from rural areas were 5.46 times more likely to exhibit low cardiorespiratory and muscular fitness compared to girls who live in urban areas. SES was not associated with CRF. Three limitations mentioned by the authors were the cross-sectional nature of the study (which does not allow for causal direction), the lack of control over motivation of students who took the field test, and the exclusion of geography and ethnicity which “could have affected the result” (p. 310).

Bohr et al. (2013) performed a cross-sectional study to determine the differences between 954 boys and girls in Grades 6 through 8. They also examined the likelihood of not meeting the FITNESSGRAM® HFZs for fitness tests, including the PACER test, between low and high socioeconomic groups. The ethnic composition of the school was a majority of White (59.0%) students as well as Black (24.5%), Hispanic (8%), Multicultural (4.9%), and Native American (> 1%) students. A majority of the students received free or reduced lunch ($n = 463$), and groups were stratified by gender and SES.

The MANCOVA analysis revealed that SES (as measured by free or reduced lunch) did not have a significant main effect on CRF (or other tests) in boys for CRF ($p = .773$). However, a main effect for the girls was in the low and high SES groups. Girls from the lower SES group had significantly fewer laps in the PACER test than did those from the high SES group ($p = .001$). The logistic regression analysis showed no significant association between boys from the low and high SES groups and the likelihood of not achieving the HFZs for CRF, *OR* = 1.162, 95% CI [0.791, 1.706]; however, there was a significant association between low SES and high SES girls. Girls from the low SES group were 2.3 times more likely not to achieve the HFZ standard for PACER laps, $p < .05$, 95% CI [1.5–3.7].

Several limitations were mentioned in this study. The authors stated that the cross-sectional nature of the study is a weakness because cross-sectional studies cannot infer causality. The use of free or reduced lunch as an indicator of SES is limited because SES consists of income, occupation, and education (Galobardes et al., 2006). Actual income data were not collected in this study. This could have been more representative of poverty status than of the proxy measure of free or reduced lunch. Also, BMI was not controlled for in the investigation, but BMI has been shown to be highly related to CRF (Dagen, Segev, Novikov, & Danker, 2013).

Finger, Mensink, Banzer, Lampert, and Tylleskär (2014) performed a cross-sectional study that examined the associations SEP, aerobic fitness, and other covariates in 11- to 17-year-old students. The sample size consisted of 5,251 youths (2,677 boys and 2,574 girls). Aerobic fitness was assessed by means of a standardized maximum cycle ergometer test, and SEP was measured by multiple questionnaires about household income, parental occupation, and parental education. Hierarchical logistic regression analysis revealed that when only age and region were accounted for, boys were more likely to have higher aerobic fitness if the following were true: their parents had higher education, *OR* = 1.6 and 95% CI [1.2, 2.1]; and their parents had middle- to high-level occupations (*OR*s = 1.4 times and 1.3 times more likely, 95% CI [1.2, 1.7 and 1.1, 1.6, respectively]. These associations disappeared when other covariates were added to the model.

In the basic logistic regression model, girls were more likely to have high aerobic fitness if the following were true: their parents had secondary or tertiary level education, *OR* = 1.5 and 95% CI [1.2, 1.9]; *OR* = 1.9 and 95% CI [1.4, 2.5], respectively; their parents had middle-to-high occupational status, *OR* = 1.3 and 95% CI [1.1, 1.6]; their parents had high occupational status, *OR* = 1.7 and 95% CI [1.3, 2.0]; or their parents had high income, *OR* = 1.5 and 95% CI [1.2, 1.8]. When other models were created that adjusted for other covariates, only parental education (secondary level) remained significant, *OR* = 1.4 and 95% CI [1.1, 1.8]. Limitations in this study included the cross-sectional design of the study and the use of a sub-maximum exercise test, which is a less accurate test (however, maximal tests were not practical). Missing data could have also biased the outcome.

Chillón et al. (2011) performed a similar study to Minatto et al. (2012) by examining the health-related physical fitness differences among 2,569 rural and urban youths in Spain. Unlike the former study, Chillón et al. (2011) used the EUROFIT test battery, the 20-meter shuttle run, and the FITNESSGRAM® cut-off values to dichotomize CRF into healthy versus unhealthy. ANCOVA analysis was used to determine differences in physical fitness components between those who live in urban versus rural settings.

Logistic regression analysis (adjusting for gender and age) was used to investigate the association between place of residence and CRF. The ANCOVA revealed a statistically significant mean difference among the youths who lived in rural versus urban settings. Those in rural settings had higher CRF levels than did those who lived in urban settings, $p < .001$, mean difference of 1.5 ml/kg/min, $d = 0.30$. Similarly, the logistic regression showed that youths who lived in rural settings were two times more likely to have healthier CRF than were those who lived in urban settings, $OR = 2.05$ and 95% CI [1.49–2.84], $p < 0.001$. There was a significant gender-by-setting interaction. Unlike the Minatto et al. (2012) study, stratified analysis found that girls from rural settings were 3.59 times more likely to have healthier CRF than were boys, 95% CI [1.90–6.76]; OR = 1.66 and 95% CI [1.13–2.44], $p = 0.01$, respectively. The limitations of this study include the lack of inclusion of SES as an influence of CRF, no measurements of the influence of maturation, and the inability of cross-sectional studies to determine causal direction.

Santos et al. (2011) performed a study to determine the association of age, gender, ethnicity, and body fat on CRF in a convenience sample of 266 youths (112 boys, 154 girls). The sample consisted of 80 Caucasian boys, 109 Caucasian girls, 32 African Portuguese boys and 45 African Portuguese girls, and they were 12 to 18 years of age. Cardiorespiratory was assessed with the 20-meter shuttle run, and scores were converted to VO_2 max using the FITNESSGRAM® software. A two-way ANOVA was used to assess gender and ethnic differences while multiple regression analyses were used to assess the relationship between VO_2 max and the sociodemographic variables of ethnicity, gender, and other variables.

Interactions were also analyzed. The ANOVA analysis revealed that girls had lower CRF than did boys (ß = 0.004, $p = 0.001$) and that African Portuguese girls had higher VO_2 max values than did Caucasian girls ($p < 0.05$). The main effects of ethnicity and age showed that both were associated with CRF, but the relationship was age-dependent (ß = -0.001, $p < 0.01$). Older Caucasians and girls had lower CRF than did younger girls. Disparities existed before and after the age of 14 years old. In sum, age affects gender and ethnic differences in VO_2 max. Limitations of this cross-sectional study are the lack of measurement of physical activity and the exclusion of maturation as a predictor variable in the models. Another limitation is that these results cannot be generalized to other ethnicities or geographic locations.

Critique of Methods

As with most cross-sectional studies, many of the studies mentioned in this review contained issues because of the methods used in this study. Cross-sectional studies can only show associations between variables and cannot infer causality. However, a statistical pooling of outcomes from high quality cross-sectional studies could yield compelling information about the association between study variables and the likelihood of outcomes (Ho, Peterson, & Masoudi, 2008). Heterogeneity existed with regard to the physical fitness battery used (FITNESSGRAM®, EUROFIT, etc.) to assess physical fitness. Many studies used the 20-meter shuttle run to test cardiovascular fitness, and others used a sub-maximum bicycle test. Most of the physical fitness batteries used cardiorespiratory tests that were criterion-referenced measures to assess whether individuals were fit versus unfit. A single study (Bohr et al., 2013) was performed in the US and Germany (Finger et al., 2014), but most studies cited were performed in Brazil, Portugal, or Spain, which may not be generalized to other populations and settings.

Lastly, only a few of the studies that were reviewed showed consistency with regard to the association among SEP, gender, ethnicity, and CRF.

Knowledge Gap

Using cross-sectional designs is beneficial to public health professionals and educators because the results can be used to guide future physical activity and physical fitness interventions or to evaluate current interventions (Knuth & Hallal, 2009). Reviews such as the one performed in Chapter 2 only serve as a subjective way to decide on policy, curriculum, and instruction. A more objective way to assess the data is statistically pooling the results from each study into an average effect size (assuming the information from the studies are valid; Pai et al., 2004). I am unaware of any published meta-analyses that have examined the association of gender and SEP on the likelihood of low CRF. As reflected by Ceasar et al. (2013), clear association among age, gender, and other sociodemographic factors on CRF is not definitive. As such, I want to close this gap by performing a meta-analysis to investigate the association between gender and SEP with CRF in adolescents.

Summary

The low physical activity levels and fitness among adolescents continues to be an ever-increasing problem. Adult studies have shown the physical and socioeconomic costs of unhealthy behaviors, such as physical inactivity. These physical and economic costs occur because of the chronic conditions associated with unhealthy behaviors, like being physically inactive. If health behaviors and chronic health conditions (e.g., glucose impairment, diabetes mellitus) that are acquired during adolescents truly do tend to track into adulthood, then chronic conditions related to physical inactivity could potentially have an even greater impact on the economic and socioeconomic health of adolescents and adults. Certain populations are disproportionately affected by chronic disease. Disenfranchised and vulnerable populations are generally affected the most. Perhaps one way to provide evidence concerning the association of gender, SEP, and CRF is to statistically pool the available studies that investigate this association.

The conceptual framework that will be used to guide this investigation is the conceptual framework for physical fitness measures, modifying factors, and health markers/outcomes in youth. Within the last five years, a few studies in English have examined the relationships between sociodemographic variables, such as gender, SEP, and CRF. The researchers who developed the conceptual framework used in this study only performed a review of studies; however, they did not perform a meta-analysis to answer the question of whether the factors they called modifiers yield a significant size effect when considered together in a meta-analysis.

The studies reviewed for the purposes of this research project differed in study population, sample sizes, age, geographic location, and a few used different instruments to measure CRF. These issues create uncertainty about the applicability of results in settings and under different conditions. With this in mind, meta-analytic investigation is needed to statistically pool the results from each study to observe if there is an association between gender, SEP, and the outcome of CRF. The proposed methods used to investigate these associations are located found in the next chapter.

Chapter 3: Research Method

Introduction

Recent studies have shown that roughly 55% of U.S. adolescents have low CRF (Gahche et al., 2014). Past researchers have also suggested similar deficiencies in CRF (Carnethon et al., 2005; Pate et al., 1996). Some studies have shown differences in CRF between males and females and those with different SEP. The overall impact of these differences, however, is unclear. This rationale led Ceasar et al. (2013) to conclude that more research is needed to better describe these associations. The first objective of this meta-analytic investigation was to examine if gender is associated with CRF, and the second objective was to examine the association between SEP and CRF in adolescents. In order to accomplish the task of determining the associations between these variables, this chapter covers the rationale for using this observational study and other considerations that are pertinent to this investigation. Also discussed is the usefulness of meta-analysis and why meta-analysis was an appropriate design to answer the research questions and the plan of action for answering the research questions.

Research Design and Rationale

Variables in This Study

This investigation consisted of two research questions, and each research question yielded two research hypotheses. These research questions and hypotheses allow readers to fully understand the research design and rationale. Each research question with their respective hypotheses are as follows:

1. Is gender associated with cardiorespiratory fitness in adolescents?

    1a. Null Hypothesis (H_{01}): Gender is not associated with cardiorespiratory fitness in adolescents.

    1b. Alternative Hypothesis (H_{A1}): Gender is associated with cardiorespiratory fitness in adolescents.

2. Is socioeconomic position associated with cardiorespiratory fitness in adolescents?

    2a. Null Hypothesis (H_{02}): Socioeconomic position is not associated with cardiorespiratory fitness in adolescents.

    2b. Alternative Hypothesis (H_{A2}): Socioeconomic position is associated with cardiorespiratory fitness in adolescents.

In this analysis, gender and SEP are the primary independent variables that are being considered, and the outcome variable is cardiovascular fitness. CRF will be measured as a continuous outcome variable (VO_2 max or distance covered over time). Moderating variables considered for this investigation include age, sample size, study design, and country.

Connection to Research Questions and Rationale for Meta-Analysis

This section will offer an explanation for the use of meta-analysis to answer the aforementioned research questions and hypotheses; it will also include descriptions about the time constraints and resources needed to conduct the meta-analytic investigation. The purpose of this study was to answer the questions of whether current evidence shows the existence of an association between gender, SEP, and the outcome of CRF. A quantitative analysis was appropriate for this research study because all the data that were used to answer the research questions and answer the hypotheses were quantitative in nature.

Meta-analysis is a synthesis of studies and seeks to answer research questions and test hypotheses by understanding individual studies in relation to similar studies (Borenstein et al., 2009). By statistically pooling the effect sizes of individual studies, researchers can determine the consistency or inconsistency of results (Cleophas & Zwinderman, 2007). By combining individual studies, meta-analyses can increase the overall sample size, increase statistical power of the analysis, and increase precision by reducing the confidence interval around the point estimate (Garg et al., 2008). In addition, meta-analyses can identify subgroups that are more likely to have poorer health outcomes (Nordsmann, Kasenda, & Briel, 2012). Because meta-analyses are used to make evidence-based decisions by providing an overall summary statistic from many studies, it is reasonable to use such information to make sound decisions based on the available evidence.

Another advantage of performing meta-analyses is that they can help to identify gaps in the literature (Garg et al., 2008). In some of the reviewed studies, for example, there were gender and SES group differences with regard to cardiovascular fitness. Perhaps this meta-analysis could shed light on this issue by identifying the overall strength of association between these variables and CRF. Therefore, instead of performing a cross-sectional study to investigate whether a relationship exists between the predictor variables, I sought to accumulate and statistically pool all study outcomes, determine the overall effect size, and perform a moderator analysis to note any differences in subgroups.

Time and Resource Constraints

The time needed to conduct a thorough search, abstraction, review, and documentation for all relevant literature was time consuming, and I was aware of the time limits that were imposed to complete the dissertation process. Examining study quality, extracting the data, and analyzing the data of published and unpublished literature was laborious. It was also difficult to retrieve unpublished literature that pertained to this topic, so only published studies were included. Language constraints were also problematic because I located several articles that were in Spanish; however, the funding needed to translate these articles was not feasible.

Methodology

Meta-analyses are observational studies that use outcomes from existing studies to gain evidence-based knowledge about a given topic. Meta-analyses allow researchers to gain this knowledge by combining data from two or more studies to increase power, improve precision, and, to a certain degree, establish more generalizable results by including different study characteristics. This section includes a discussion about the method used for (a) identifying the population of interest from potentially relevant studies via inclusion and exclusion criteria, (b) acquiring relevant literature, (c) screening articles, and (d) extracting data.

Population of Study

The focus of this meta-analysis was the role that gender and SEP played in CRF in adolescents. The WHO defines adolescents as youths between the ages of 10 and 19 years old (WHO, 2014). This definition was used for the purposes of this study because it was assumed that studies conducted in other countries would have assessed the CRF of youths in this age range. I considered youths from 11 to 18 years old because these ages are more reflective of youths who attend schools at secondary educational settings. Reports have documented the high prevalence of poor CRF in adolescents (Gahche et al., 2014), and this trend could lead to future increases in health-care costs as these youths track into adulthood.

Sampling and Sampling Procedures

Studies that were reviewed for this meta-analysis examined the association between gender, SEP, and the outcome of CRF. A comprehensive search strategy was conducted to locate primary studies concerning this topic. All studies used in this investigation underwent a power analysis to reduce the number of underpowered studies in this meta-analysis.

Statistical power is the likelihood of a null hypothesis statistical test to detect, within a sample, the existence of an effect or association within a population (Cohn & Becker, 2003). This is an important step in meta-analysis as others have found that including small primary studies with small samples may lack the statistical power needed to detect a meaningful effect (Littell et al., 2008). For example, Turner, Bird, and Higgins (2010) performed a study to investigate the effects of underpowered studies on meta-analyses and found that seven out of 10 studies reviewed in nearly 10,500 meta-analytic studies were underpowered. Only an estimated 9% were able to detect a power of 80%, which could affect the summary estimate of the meta-analysis. The finding also provides the rationale for investigating the number of studies that were needed to detect power in this meta-analysis.

In primary studies, increasing the sample size decreases the standard error of the mean, which increases study precision by decreasing the confidence interval around the effect size (Wilson, VanVoorhis, & Morgan, 2007). Therefore, it is important that all studies included in this investigation had adequate sample sizes. In addition to having statistical power of each study, performing a meta-analysis increased the precision of the study by reducing the standard error of the weighted effect size, thereby decreasing the confidence interval around the estimated mean of the distribution (Cohn & Becker, 2003).

Another main step in developing a meta-analysis is determining the power of the actual meta-analysis study to detect a true effect if there really is an effect (Cafri, Kromrey, & Brannick, 2009). Cafri et al. (2009) stated that researchers do not wish to invest time and resources into meta-analyses that are not likely to detect meaningful and significant effects; therefore, in addition to determining the power of primary studies within the meta-analysis, a power analysis should be performed for the meta-analysis. The power analysis for this meta-analysis is discussed later.

In sum, by synthesizing adequately powered studies and performing a power analysis, my meta-analysis should show a more accurate reflection of whether gender and

SEP are associated with the likelihood of low CRF, after accounting for covariates. The following section includes a discussion about the inclusion and exclusion criteria for this study.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria are an important feature in any study because they set the boundaries of the types of studies that will be included in the meta-analysis (Littell et al., 2008). Study characteristics, such as study designs, demographics, and outcomes, that will be included or excluded inform the reader about the boundaries for the study (Littell et al., 2008). This section includes a discussion about the a priori inclusion and exclusion criteria for this study.

Inclusion criteria. To be included in this review of literature, cohort and cross-sectional studies were required to provide statistical evidence concerning the association between genders (male/female), SEP, and a measure of CRF as an outcome.

More specifically, primary studies were included if the following criteria were met: (a) participants were 11 to 18 years of age; (b) the outcome measured an association of gender or SEP with CRF; (c) the sample size was measured and reported; (d) studies included a calculated effect size (preferably Cohen's *d* with confidence intervals or some comparable effect size calculation that could be converted) or information that could be used to calculate the size effect; (e) criterion-referenced CRF tests were used with an outcome that was continuous and based on health criteria; (f) population or school-based settings were used; (g) information about the study design was included; (h) studies were written in the English language; (i) studies were presented as full-length manuscripts.

All studies underwent a review for quality using an assessment tool that has been used in previous observational studies. All studies must also have provided information about statistical power for the study or provided information so that statistical power could be calculated.

Exclusion criteria. Studies that did not meet the aforementioned criteria were excluded from this full-length manuscript. Studies were also excluded if they only included participants who had pre-existing medical conditions (e.g., diabetes mellitus).

Search method. The literature search for this investigation began in 2009 and ended in July of 2014. The articles reviewed for this study were identified using the following databases: HighWire, CINAHL & MEDLINE Simultaneous Search, PubMed, Nursing and Allied Health Source, Google Scholar, and ScienceDirect. Keywords used for the search included *physical fitness* or *fitness* or *cardiorespiratory fitness* or *aerobic capacity* and *gender* or *sex*, and *socioeconomic status* or *socioeconomic position* or *poverty* or *social status* and *adolescents* and *teenagers* and *correlates* or *determinants* and *association*. The search was limited to published literature in peer-reviewed journals from the search engines and manual searches of journals in hard copy.

Screening of articles. All duplicates were removed, and all located articles underwent a 2-phase process. The first phase involved scanning the abstracts of each article for inclusion or exclusion. In the second phase, I obtained full copies of relevant articles that met the inclusion criteria for this investigation. All references that were related to the topic were exported into a spreadsheet.

Data extraction. All pertinent studies were finalized for inclusion and were collated and coded under the following categories: name of study, study design, type, sample characteristics, test instrument used, and results (including calculated Cohen's *d*). Articles were coded with detailed descriptive information to allow analyses (authors, title, sample size, outcome, and location of study).

Statistical Power Considerations for Meta-Analysis

When compared to single study designs, statistical power in meta-analyses is typically much greater (Matt & Cook, 1994). The increased statistical power is most evident in the ability of meta-analyses to find significance with a limited number of cases (e.g., effect sizes; Feinstein, 1995). Furthermore, given that meta-analyses are estimating a population effect size, they are inherently more adept at finding significance (Cohn & Becker, 2003). An established recommended minimum number of studies has not been required to perform a meta-analysis, but guidelines proposed have recommended as few as two studies (Valentine, Pigott, & Rothstein, 2010) to between six and 10 studies (Fu et al., 2011). For this study, a total of 18 studies were located and used in the final analyses, which, based on the recommendations, should yield sufficient statistical power (Cohn & Becker, 2003). The next section includes a discussion about the instrumentation and operationalization of constructs for the study.

Instrumentation and Operationalization of Constructs

The outcome under investigation was CRF (VO_2 max). CRF (VO_2 max) is defined as "the body's capacity to transport and use oxygen during maximal exertion involving dynamic contraction of large muscle groups, such as during running and cycling"

(Lindsay et al., 2013, p. 2). VO_2 max is the gold standard for assessing CRF (Sacheck & Hall, 2014) and is related to cardiovascular health (Buffart et al., 2008). Newer field-based, health-related fitness tests (e.g., FITNESSGRAM® battery of tests) are criterion-based assessments that measure whether individuals are fit or unfit (or health/unhealthy). Keeping in line with the association between fitness and health, all measures used in the inclusion literature should be based on health criterion-referenced tests.

The instrument used to assess the quality of the cross-sectional studies was the STROBE checklist (Von Elm et al., 2007). STROBE has been used as an assessment tool of reporting quality (Von Elm et al., 2007), but it does not assess methodological quality (da Costa, Cevallos, Altman, Rutjes, & Egger, 2011). Thus, the PRISMA (Moher et al., 2009) was used as a source to ensure that pertinent characteristics were included in this meta-analysis. These tools have been commonly used by the Cochrane Collaboration in their reviews of primary studies and meta-analyses (Higgins & Green, 2011) and were used for the purposes of this investigation.

Data Analysis Plan

The software that was used to analyze the data was CMA. This section provides an explanation of how the data were cleaned. A restatement of the research questions and hypotheses is also presented, followed by a detailed analysis of the plan for this investigation.

The research questions posed are as follows:

1. Is gender associated with cardiorespiratory fitness in adolescents?
2. Is socioeconomic position associated with cardiorespiratory fitness in adolescents?

As such, this section provides the statistical tests that will be used to answer the following hypotheses:

1a. H_0 = Gender is not associated with cardiorespiratory fitness in adolescents.

1b. H_1 = Gender is associated with cardiorespiratory fitness in adolescents.

The Cohen's *d* was used as the effect size index to calculate the association between gender and CRF. Means and standard deviations were available in all primary studies that were included in this meta-analysis; therefore, standardized mean differences were used to calculate the effect sizes (Cohen's *d*) in each study. Effect size describes the magnitude and direction of relationships between variables (Borenstein et al., 2009; Littell et al., 2008). Health study meta-analyses have used variations of *d* to detect effect sizes. For example, Saavedra et al. (2011) used *d* to assess CRF in obese children while adjusting for body weight, and Chase and Conn (2013) used standardized mean difference to calculate the mean difference effect sizes and note the effectiveness of motivational physical activity interventions on CRF outcomes in adults.

The model of choice to statistically pool the effect sizes from each was the random effects model. All computations were conducted in CMA. The alpha (α) level was set at $p < .05$ for the *z* test (2-tailed). In order to identify heterogeneity, *Q* statistics and I^2 were used. Using both tests has been suggested by Huedo-Medina, Sánchez-Meca, Marín-Martínez, and Botella (2006). Both tests are commonly used together in health-related meta-analyses (Chase & Conn, 2013; Gourlan, Trouilloud, & Sarrazin, 2011). Subgroup analyses were also performed, and all tests were set at an α of $p < .05$. Publication analysis was assessed using funnel plots, failsafe *N*, and the trim and fill method. Moderation analyses were performed for sample size, study design, age, and location of country where the studies occurred.

The second group of hypotheses included the following:

2a. H_0 = Socioeconomic position is not associated with cardiorespiratory fitness in adolescents.

2b. H_1 = Socioeconomic position is associated with cardiorespiratory fitness in adolescents.

Similar to the first research question and hypotheses, the Cohen’s *d* was used as the effect size index to calculate the association between SEP and CRF in adolescents. Means and standard deviations were available in all primary studies that were included in this meta-analysis. Therefore, standardized mean differences were used to calculate the effect sizes (Cohen’s *d*) in each study.

Effect size, or treatment effect, describes the magnitude and direction of an association between variables (Borenstein et al., 2009; Littell et al., 2008). Studies have used standardized mean differences (*d*) to detect effects in health studies. For example, Saavedra et al. (2011) used *d* to assess CRF in obese children while adjusting for body weight. Chase and Conn (2013) used standardized mean difference to calculate the mean difference effect sizes to note the effectiveness of motivational physical activity interventions on CRF outcomes in adults.

All computations were conducted in CMA. The α level was set at $p < .05$ for the z test (2-tailed). In order to identify heterogeneity, Q statistics and I^2 were used because using both tests has been suggested by Huedo-Medina et al. (2006). Both tests are commonly used together in health-related meta-analyses (Chase & Conn, 2013; Gourlan et al., 2011). Subgroup analyses were performed, and all tests were set at an α of $p < .05$. Publication analyses were assessed using funnel plots, failsafe *N*, and the trim and fill method. Moderation analyses were performed for sample size, study design, age, and location of country where the studies occurred.

Data Cleaning

Data cleaning is not a cure for poorly designed studies, but input errors can potentially impact study results (Van der Broeck, Cunningham, Eeckels, & Herbst, 2005). Logically, one of the inherent weaknesses of using the outcome of studies in a meta-analysis is the limitation of knowing if data are sufficiently clean. Studies in this meta-analysis were relevant, extracted articles that answered each research question. The data were reviewed and confirmed by another research analyst, indicating accurate extraction. The screening decisions and eligibility of the studies were mentioned in earlier sections.

The meta-analysis was performed using the CMA software, which is capable of multiple statistical procedures that aided me in this investigation. This section includes a discussion about how the effect sizes (Cohen's *d*) were calculated and about the rationale for using the random and fixed effects model. I also discuss the rationale for investigating heterogeneity, subgroup differences, publication bias, and sensitivity, followed by why the CMA software was used to conduct this meta-analysis.

Standardized Mean Difference (*d*)

Research questions and hypotheses in this meta-analysis focus on whether an association exists between gender, SEP, and CRF. To determine the strength and direction of this association, an effect size estimate was needed (Littell et al., 2008). In this meta-analysis, standardized mean differences (*d*) were used to determine the summary effect size estimate. Standardized mean differences are used to determine the difference between two group means and are expressed in common standard deviations (Cooper et al., 2010).

Cohen's *d* was determined to be the best choice for a variety of reasons. First, Cohen's *d* can be easily calculated when the mean, standard deviation, and sample size are available, which increased the number of studies that could be included in the final meta-analysis. Additionally, McGrath and Meyer (2006) noted that Cohen's *d* is favorable when making comparisons across varying sample sizes, which was the case with the obtained studies. Cohen's *d* can be interpreted as follows: .30 is considered small, .50 is considered moderate, and above .80 is considered large (Cohen, 1988; Field & Gillett, 2010).

The CMA software calculated the weighted effect sizes. As mentioned in previous sections, weighing effect sizes is important to consider. Borenstein et al. (2009) make it clear that in many cases, studies are not as precise as others; therefore, all studies are not equal. With this in mind, more precise studies should be weighted more than less precise studies (Borenstein et al., 2009). Borenstein et al. stated that the way studies are weighted will determine the combined effect. The weight of each study is dependent upon which model (fixed or random effects model) is used. The next section presents the model that will be used in this investigation and why it is preferred over the other model.

Fixed Effects Model or Random Effects Model

Two basic models are used in meta-analyses: fixed effects models and random effects models (Borenstein, Hedges, Higgins, & Rothstein, 2010). The differences between each model are the assumptions of each. For example, fixed effects models are based on the assumption that all primary studies have and surround the one, true effect size and that the size effect of each study is an estimate of this single, true effect size (Borenstein et al., 2009; Borenstein et al., 2010). Secondly, any deviation away from this true effect size is thought to be due to sampling error. Borenstein et al. (2010) refer to this as the “within-study variance” (p. 99), which, in turn, can affect the precision of the study; therefore, the summary effect size is the estimated average of all of the included studies.

On the other hand, random effects models presuppose a distribution of true effect sizes, so the goal of these models is to summarize the average of this distribution (Borenstein et al., 2010). Therefore, random effects models presuppose that there is within-study variance and between-study variance. In other words, fixed effects models consider one source of variance (i.e., sampling error), and random effects models consider two sources of variance (i.e., sampling error with the study and population differences between studies; Schmidt, Oh, & Hayes, 2009).

The within-study error variance can be affected by two factors: individual observational differences within the study and the size of the sample (Borenstein et al., 2010). The computation of within-study variance (v_i) is shown below:

$$V_i = \delta^2 / n$$

This calculation shows that δ^2 is the individual observations in the population and *n* is the sample size. This computation demonstrates that a larger sample size will increase the precision of the population mean. In other words, a larger sample size is more reflective of the population mean and is, thus, more precise. In keeping with this phenomenon, weighting in meta-analysis that relies on the fixed effects model uses the following computation to weigh studies:

$$w_i = 1/v_i$$

In this computation, w_i is the weight of the primary study, v_i is the study variance, and v_i is divided by 1 (inverse) to yield the study weight; it is known as inverse variance weighting (Borenstein et al., 2010). An issue with fixed effects models is that they assume that populations are homogeneous and neglect to account for different size effects as a result of having a distribution from an infinite “superpopulation” (Field, 2003).

Primary studies within a sample are only a “snapshot” of all possible studies that could be done on the topic and not the model for the entire population (Field, 2003). These differences become important when considering the weighting of studies in a meta-analysis under each model. In fixed effects models, only within-study variability is considered when weighting a study because it is assumed that every other unknown is fixed (Field, 2003). However, random effects models are considered both within-study variability (i.e., sampling error) and between-studies variability (i.e., differences between populations, also known as standard errors; Field, 2003). Accounting for the between-study variations leads to a more conservative effect size and estimate precision. When comparing the pooled summary effects of fixed effects models to those of random-effects models, the pooled estimates are wider and less precise than are those of the fixed effects models. However, they are more representative of real world data because they account for differences in populations.

In fixed effects models, it is assumed that there is a fixed true effect size and that any deviation from this true effect size is due to error. An equation was given to indicate that a change in sample size will affect precision: The greater the sample size, the greater the precision of the estimate. This is due to larger sample sizes producing observations that are more reflective or the assumed true effect size. In the fixed effects model, this would favor and give more weight to larger studies because larger studies are more precise (Borenstein et al., 2009). However, fixed effects models do not account for between-study variances because they assume that all other factors are constant (Field, 2003).

The random effects models, however, assume that differences will exist at the population level and that there are infinite sample effect sizes. The sample effect sizes that are captured in primary studies only represent some of the distribution of effect sizes, and an average of these effect sizes will provide an estimated effect size that is reflective of the real world (Field, 2003). Unlike fixed effects models, which disregard smaller studies and/or weight them lower than they do larger studies, random effects models give them more weight, even though they are less precise; this is because they also reflect the distribution of effect sizes that exist. In essence, large and extreme studies will lose weight, and smaller studies will gain influence (Borenstein et al., 2009).

In within-study variances, errors are unique to each study because these variances rely heavily on the sample size; however, between-study variances (τ^2) is common between studies. When estimated size effects are used from each study to estimate the grand population mean (μ), both within- and between-study variances must be considered (Borenstein et al., 2010). Therefore, tau-squared (τ^2) becomes a part of the denominator (in random effects modeling) and is added to the within-study variance:

$$w_i = 1/v_i + \tau^2$$

Basic mathematics revealed that as the denominator increases, the weight decreases. As such, the weight of larger studies decreases, and smaller studies are weighted to reflect more balance. Assuming there is no between-study variance, the weights automatically reflect the weights for the fixed effects model (i.e., no heterogeneity exists; Borenstein et al., 2010).

Once all studies have been weighted, a calculation of the mean effect size is performed across all studies. As shown in Borenstein et al. (2009), the following is the computation for weighting the average combined effect:

$$\bar{T}_{\cdot}^{*} = \frac{\sum_{i=1}^{k} w_i^* T_i}{\sum_{i=1}^{k} w_i^*}$$

Calculating the precision of the combined average effect size is also important. As stated previously, random effects models are not as precise as are fixed effects models because the assumption is that there is a distribution of effect sizes, and from these effect sizes, an average effect size is calculated. Therefore, the random effects model will account for within-study and between-study variance. There are two ways that random effects calculates variances: standard error and confidence intervals (Borenstein et al., 2009).

$$SE(\bar{T}.^{*}) = \sqrt{v.^{*}}$$

Standard error for the weighted effect size in the random effects model is equal to the square root of variance. Once the standard error has been calculated, the lower and upper limit confidence intervals (CI) can be calculated (Borenstein et al., 2009).

$$Lower\ Limit^{*} = \bar{T}.^{*} - 1.96 * SE(\bar{T}.^{*})$$

$$Upper\ Limit^{*} = \bar{T}.^{*} + 1.96 * SE(\bar{T}.^{*})$$

A *z* score can be produced by dividing the weighted effect size calculated under the random effects model and dividing that by the product of standard error and the weighted effect size (Borenstein et al., 2009). The *z* score will indicate statistical significance, depending on whether researchers use a one-tailed or two-tailed test (Borenstein et al., 2009).

$$Z^{*} = \frac{\bar{T}.^{*}}{SE(\bar{T}.^{*})}$$

In this meta-analysis, the random effects model was used because of the diversity between the primary studies. For example, gender, SEP, and geographical differences existed between studies. Another advantage of using the random effects model was that if the differences between studies approximated zero, then the model would look similar to the fixed effects model. Using the fixed effects model would not allow for corrections if between-study differences exist. The literature noted several researchers who have used random effects models to conduct meta-analytic studies in health-related fields of study (Gist, Fedewa, Dishman, & Cureton, 2014; Chase & Conn, 2013). Due to the expected diversity in this study, I used the random effects model. The statistical significance was set at $p < .05$, and the results were presented with confidence intervals (95% CI).

Comprehensive Meta-Analysis (CMA) Software

A tabulation of study characteristics and results (coded as author names and years of publication) was entered into CMA software (Comprehensive Meta-Analysis, Version 2). CMA software was developed by Biostat Incorporated and provided the following procedures that were needed for this meta-analysis: effect size measures, the inclusion of multiple design within the same analysis, fixed and random effects models, subgroup analyses, sensitivity analysis, analysis of variance to assess categorical moderators (moderation analysis), and tools to detect publication bias (i.e., funnel plots, Rosenthal's failsafe *N*, and Duval and Tweedie's trim and fill; Comprehensive Meta-Analysis, Version 2).

Forrest plots were used to show the individual effect sizes and confidence intervals from each study. I examined the following information: (a) outcome measure for each study, (b) pooled estimate effect, and (c) heterogeneity (differences in the true effects underlying the studies). Because heterogeneity can occur by chance when analyzing the data, I^2 and Q statistics were used to quantify heterogeneity in this meta-analysis. The literature has suggested that this statistic should be presented to show the proportion of the total variation that is due to study differences (Higgins & Thompson, 2002). I then pooled the effect measures from all the studies to compute weighted averages. Each study may have had different sample sizes, so all the studies were not weighted the same (Pai et al., 2004). Studies that contained larger sample sizes were weighted more in the computed averages. Effect sizes were presented with 95% confidence intervals, and $p < .05$. The aforementioned statistical tests have been used in meta-analyses that focused on fitness outcomes in recent years (Chase & Conn, 2013).

A random effects model was used in this meta-analysis because the studies were assumed to be a random sample of all possible studies for the stated research questions, and the data may have been heterogeneous; also, the true effect may have varied because of the differences between samples and studies (Littell et al., 2008). Using random effects models provides conservative estimates if heterogeneity exists, but if no heterogeneity exists, then similar results are presented in the outcome. With this in mind, I used a random effects statistical model to pool the effects. If trivial variation is detected, then the mean effect size and confidence interval will be reported. If heterogeneity is significant, then potential sources of variability in the estimates are investigated by performing a subgroup/moderator analysis. Moderator analyses helped to pinpoint differential characteristics that led to the variability across the examined studies (Borenstein et al., 2010; Lipsey, 2003). The random effects model and moderator analysis were used to analyze fitness outcomes from physical activity interventions (Chase & Conn, 2013). Additionally, the CMA software were used to perform these analyses.

Threats to Validity

A major threat to internal validity in meta-analyses is publication bias (Pai et al., 2004). Publication bias occurs when results of studies included in the meta-analysis have not been represented in the pooled estimates of all the studies (Littell et al., 2008). Funnel plots, Rosenthal's failsafe *N*, and Duval and Tweedie's trim and fill method were used to assess for publication bias (Borenstein, 2005). A funnel plot is a visual tool that is used to estimate the size effects of individual studies (Sterne & Harbord, 2004). Asymmetry existed from a visual inspection of the funnel plot; therefore, the failsafe *N* and the trim and fill method were performed, similar to other meta-analyses that were assessed for publication bias (Maniccia, Davison, Marshall, Manganello, & Dennison, 2011).

Threats to external validity include the inability to generalize to all populations and settings. With the inclusion and exclusion criteria, the results can only be generalized to the population and settings from which the reviewed studies come. Steckler and McLeroy (2008) stated that "systematic reviews and meta-analyses are limited in the conclusions that can be drawn when external validity data are not reported" (p. 10). Therefore, the reviewed studies can only be generalized to the population, settings, and context in which they were investigated (Littell et al., 2008). However, it is worth noting that meta-analyses could potentially indicate the need for more studies to investigate phenomenon for different settings, populations, and contexts. It is reasonable to conclude that these studies, in turn, may lead to further studies concerning the association of sociodemographic factors with CRF. The PRISMA checklist was used to comply with many of the items needed for meta-analyses (Moher et al., 2009).

Ethical Procedures

The study was approved by Walden Institutional Review Board before the collection of data began (IRB approval number 11-03-14-0137681). This retrospective data analysis did not involve the recruitment of any human participants; therefore, there were no ethical concerns for human subjects. The data were collected from primary studies found in research databases and at libraries of higher education located in the local area. The type of data used was accessible research articles found on the aforementioned databases and at one university library; therefore, privacy and confidentiality issues do not apply.

Summary

The aims of this retrospective, cross-sectional study were to (a) determine if gender is associated with CRF in adolescents; and (b) determine the association of SEP with CRF in adolescents. Power analyses were used to ensure that each primary study has adequate sample size. The instrument used to measure the outcome has been studied and has been shown to be a valid and reliable way to measure aerobic capacity. The characteristics needed to answer the research questions were entered into CMA software to produce an overall weighted summary estimate. Forrest plots were conducted to examine field effect and individual study effects. Moderation analyses were conducted to examine how age, sample size, study design, and country of origin impact the association between gender and CRF. Moderation analyses were also performed to examine how proposed moderators impact the association between SEP and CRF. The next chapter presents the results of this investigation.

Chapter 4: Results

Due to an increase in chronic diseases at earlier ages and in different socioeconomic and geographic locations, the purpose of this observational study was to determine the association of gender and SEP with the outcome of CRF in adolescents. The magnitude of association between gender, SEP, and CRF is important because determining the overall association is the first step in creating evidence-based interventions designed to increase physical activity among this population. To the degree that CRF and other health-related physical fitness components are powerful markers of health, more effective health policies and gender-specific interventions in socioeconomically disadvantaged settings could result in increased physical activity and healthier adolescents as they transition into adulthood. In an attempt to determine the overall magnitude of the association between gender, SEP, and CRF, the outcomes were specified and the research questions were formed based on the associated outcome.

Two research questions were formulated for this study. The first question dealt with the association of gender and CRF in adolescents. The second question dealt with the association between SEP and CRF in adolescents. Moderator analyses were performed for age, sample size, study design, and the country where the studies were conducted where appropriate. The purpose of Chapter 4 is to describe the data collection procedures, to describe the included studies in this meta-analysis, and to discuss the overall results of the meta-analysis, including moderator analysis, and the assessment of publication bias.

Data Collection

Data Collection Procedures

A comprehensive search was conducted to locate pertinent published articles that provided primary research articles pertaining to the association of gender and SEP on CRF from 2009 until July of 2014. Using the STROBE guidelines for cross-sectional studies (Von Elm et al., 2007) and the PRISMA guidelines (Moher et al., 2009) for the background of the study, research questions, meta-analysis methods, inclusion and exclusion criteria, search strategy, and statistical procedures were identified in the research methods chapter.

The independent variables in the meta-analysis were gender and SEP. CRF was the single outcome variable for this meta-analysis. To identify pertinent literature related to the association of gender and SEP with CRF, a comprehensive search of the literature was performed electronically.

Search Strategy for Pertinent Studies

In an attempt to identify the pertinent primary research articles needed for this meta-analysis, a comprehensive search was performed in multiple databases for studies that investigated the association between gender and CRF and SEP and CRF. A search was also performed for pertinent literature by examining printed journals and by searching the reference section in the back of each article. The keywords that were used to identify pertinent articles were mentioned in Chapter 3.

The search strategy that was used was based on the strategy noted in the PRISMA statement (Liberati et al., 2009). Liberati et al. (2009) stated that the search strategy should consist of identification, screening, eligibility, and inclusion of literature. In the identification step, the number of records identified in each database was recorded as well as any pertinent literature noted in other sources. While screening the titles and abstracts, all duplicates were removed and the numbers of pertinent articles remaining were screened. The remaining titles and abstracts that were pertinent to the research questions were recorded while those that did not were recorded then excluded from the meta-analysis. In the eligibility step, a review of the all full-text articles was conducted and assessed for eligibility. All articles found not to be relevant were excluded. An explanation ensued to reveal why each article was excluded. Finally, the number of primary studies that met the inclusion criteria for this meta-analysis was used for this quantitative synthesis.

Search Process Documentation

A record of the literature search was maintained while collecting the information that was needed for this meta-analysis. The following information was collected during the collection process: the research databases searched, the dates in which the searches were performed, and the number of yielded as a result of the search. Most of the data were collected via the Walden Library system; however, other research articles reviewed for this meta-analysis were found in databases that were not found at Walden University. Full-text articles that were not found at the Walden University Library were found at local universities located 50 minutes away.

Results

The primary purpose of this dissertation was to examine the effects of potential contributing factors on CRF. Specifically, this meta-analysis aimed to examine potential differences in CRF as a function of gender and SES. This chapter outlines the specific statistical analyses conducted and the results of all statistical findings.

Coding and Extraction Process

A total of 18 studies were identified as meeting inclusion criteria for this meta-analysis and reporting the necessary information to calculate a sample-specific effect size. Upon further investigation of reported data across studies, it was determined that the effect sizes for each study would be calculated as Cohen's *d*, which measures the magnitude of change across standardized mean differences. Cohen's *d* was determined to be the best for a variety of reasons. First, Cohen's *d* can be easily calculated when the mean, standard deviation, and sample size is available, which increased the number of studies that could be included in the final meta-analysis. Additionally, McGrath and Meyer (2006) have noted that Cohen's *d* is favorable when making comparisons across varying sample sizes, which was the case with the obtained studies. Cohen's *d* can be interpreted as follows: .30 is considered small, .50 moderate, and above .80 large (Cohen, 1988; Field & Gillett, 2010).

Raw data were extracted from original studies. Following initial data extraction, 15% of the data were verified and no errors were found with extraction. Next, *d* was calculated using Cohen's (1988) formula as follows:

$$d = \frac{M_1 - M_2}{\sigma}$$

A summary of the extracted data and calculated effect size is outlined in Table 1. Multiple effect sizes from one study were retained so long as each effect size represented a single sample. For example, Castro-Pinerio et al. (2011) reported descriptive statistics for key outcomes separated by participant age, and three effect sizes were calculated for this one study. Studies with multiple effect sizes have been identified in Table 1 with a subsample description following the year of publication. As further shown in Table 1, a total of 41 effect sizes were available ($k_{\text{gender}} = 33$; $k_{\text{ses}} = 8$).

In addition to extracting the raw data to compute a study specific effect size, study characteristics were coded to be used as categorical. A summary of the frequencies and total effect sizes are outlined in Table 2. For studies related to gender, sample size was coded into two groups (i.e., small and large), with total samples under 1,000 being coded as small and samples over 1,000 being coded as large. For studies related to SES, studies with fewer than 500 participants were categorized as small and studies with greater than 500 participants were categorized as large. Sample size was categorized into these groupings in order to retain relatively equal sizes across groups. Additional categorical moderators were categorized for country of study, study design and statistical method employed, and age where available (less than 16 years old and 16 years or older). Study design was categorized into two groups, including studies that examined tests of difference, such as *t* tests and analysis of variance (ANOVAs), and those that employed predictive analyses, such as regressions.

Table 1

Summary of Extracted and Calculated Data

		Males			Females			
Study	Outcome	*N*	*M*	*SD*	*n*	*M*	*SD*	*d*
Liao et al. (2013)	800-m Run	6750	302.10	70.20	6750	304.60	60.30	-.038
Silva et al. (2013)	VO_2max	127	52.50	6.80	183	41.40	4.60	1.980
Aires et al. (2011)	VO_2max	789	38.43	3.16	919	32.42	2.83	2.012
Minatto, Petroski, & Santos Silva (2013)	VO_2max	141	44.27	4.56	127	40.64	5.08	.754
Santos et al. (2011 - Caucasian)	VO_2max	80	45.00	6.20	109	36.20	4.90	1.604
Santos et al. (2011 – Afr. Portuguese)	VO_2max	32	45.60	6.30	45	38.80	4.90	1.232
Minatto et al. (2012)	VO_2max	138	44.23	4.62	128	40.56	5.12	.754
Petroski et al. (2012*)	Aerobic Fitness							.745
Sandercock et al. (2013)	VO_2peak	3966	45.70	6.20	3500	41.30	4.90	.782
Castro-Pinerio et al. (2011 - 12-13 yr)	20m Shuttle	237	5.50	2.20	195	4.30	1.90	.580
Castro-Pinerio et al. (2011 - 14-15 yr)	20m Shuttle	237	6.70	2.50	195	4.20	2.00	1.093
Castro-Pinerio et al. (2011 - 16-17 yr)	20m Shuttle	237	6.60	2.50	195	3.90	1.70	.530
Hsieh et al. (2014)	800m run	1230	276.65	64.41	1189	287.13	3.69	-.228

Note. *Cohen’s *d* estimated from other data available.

Table 1, *continued*

Summary of Extracted and Calculated Data

		Males			Females			
Study	Outcome	*N*	*M*	*SD*	*n*	*M*	*SD*	*d*
Chillón et al. (2011 - Child)	VO_2max	550	48.50	4.00	518	46.30	3.50	.584
Chillón et al. (2011 - Adolescent)	VO_2max	770	47.30	5.90	726	41.30	5.20	1.077
Santos et al. (2014 - 11 yrs)	20m Shuttle	1142	33.20	15.00	1161	24.30	10.90	.680
Santos et al. (2014 - 12 yrs)	20m Shuttle	1239	36.00	16.90	1189	26.70	12.30	.627
Santos et al. (2014 - 13 yrs)	20m Shuttle	1357	42.10	19.50	1364	29.10	13.30	.783
Santos et al. (2014 - 14 yrs)	20m Shuttle	1157	48.90	21.60	1186	29.70	12.50	1.091
Santos et al. (2014 - 15 yrs)	20m Shuttle	1387	56.10	21.90	1414	30.70	12.90	1.417
Santos et al. (2014 - 16 yrs)	20m Shuttle	1535	61.60	22.30	1695	32.10	13.60	1.647
Santos et al. (2014 - 17 yrs)	20m Shuttle	1372	66.20	21.70	1662	33.60	12.20	1.900
Santos et al. (2014 - 18 yrs)	20m Shuttle	1177	67.10	22.00	1010	32.70	13.30	1.860
Jiménez-Pavón, Ortega, Ruiz, España Romero, et al. (2010 - Lo)	20m Shuttle	270	5.80	2.60	314	3.10	1.90	1.200
Jiménez-Pavón, Ortega, Ruiz, España Romero, et al. (2010 - Med)	20m Shuttle	270	6.80	2.60	314	3.80	1.90	1.333
Jiménez-Pavón, Ortega, Ruiz, España Romero, et al. (2010 - High)	20m Shuttle	270	7.20	2.60	314	4.60	1.90	1.155

Note. *Cohen's *d* estimated from other data available.

Table 1, *continued*

Summary of Extracted and Calculated Data

		Males			Females			
Study	Outcome	*N*	*M*	*SD*	*n*	*M*	*SD*	*d*
Lobelo et al. (2009 - 12 - 15 yrs)	CRF	308	47.00	8.60	315	39.70	7.50	.905
Lobelo et al. (2009 - 19-19 yrs)	CRF	369	48.10	9.50	255	38.90	8.60	1.006
Jiménez-Pavón, Ortega, Ruiz, Chillón, et al. (2010 - Low)	20m Shuttle	241	6.90	1.55	266	4.20	1.63	1.695
Jiménez-Pavón, Ortega, Ruiz, Chillón, et al. (2010 - Med)	20m Shuttle	241	6.90	1.55	266	4.10	1.63	1.758
Jiménez-Pavón, Ortega, Ruiz, Chillón, et al. (2010 - High)	20m Shuttle	241	7.20	3.10	266	4.60	3.26	.816
He et al. (2011 - Normal Weight)	CRF	724	48.17	2.96	814	45.15	2.57	1.091
He et al. (2011 - Overweight/Obese)	CRF	117	40.75	2.49	80	38.61	2.41	.871

Note. *Cohen's *d* estimated from other data available.

Table 1, *continued*

Summary of Extracted and Calculated Data

Study	Outcome	Low SES *N*	Low SES *M*	Low SES *SD*	High SES *n*	High SES *M*	High SES *SD*	*d*
Aires et al. (2011*)	VO_2max							-.024
Fahlman et al. (2006)	1-Mile Run	604	10.20	1.40	710	14.20	2.40	-1.997
Bohr et al. (2013 - F)	PACER Laps	222	28.00	1.10	221	37.00	1.10	-8.182
Bohr et al. (2013 - M)	PACER Laps	178	46.00	1.78	223	46.00	1.59	.000
Jiménez-Pavón, Ortega, Ruiz, España Romero, et al. (2010 - M)	20m Shuttle	270	5.80	2.60	270	7.20	2.60	-.539
Jiménez-Pavón, Ortega, Ruiz, España Romero, et al. (2010 - F)	20m Shuttle	314	3.10	1.90	314	4.60	1.90	-.790
Jiménez-Pavón, Ortega, Ruiz, Chillón, et al. (2010 - M)	20m Shuttle	241	6.90	1.55	241	7.20	3.10	-.122
Jiménez-Pavón, Ortega, Ruiz, Chillón, et al. (2010 - F)	20m Shuttle	266	4.20	1.63	266	4.60	3.26	-.155

Note. *Cohen's *d* estimated from other data available.

Table 2

Summary of Studies and ES by Moderators

	Gender		SES	
	K	%	K	%
Sample Size				
Small	15	45.5	3	37.5
Large	18	54.5	5	62.5
Country				
Asia	4	12.1	-	-
Brazil	3	9.1	-	-
England	1	3.0	-	-
Portugal	15	45.5	1	12.5
Spain	8	24.2	4	50.0
US	2	6.1	3	37.5
Design				
Tests of Difference	20	60.6	-	-
Predictive Analyses	13	39.4	-	-
Age				
Less than 16 Years Old	8	61.5	-	-
16 Years or Older	5	38.5	-	-

Note. Percentages shown are valid percents.

Gender Analyses

The first research question examined the potential impact of gender on CRF. In order to test this research question, a meta-analysis was conducted using CMA v2. A summary of the meta-analysis testing gender differences on CRF is shown in Figure 2. All of the individual effect sizes were significant, indicating an impact of gender on CRF. All but two studies found a positive effect, indicating that males tended to have greater CRF when compared to females. Examination of the heterogeneity across studies indicated substantial heterogeneity, $Q\ (32) = 5398.00$, $p < .001$, $I^2 = 99.41$. What this indicates is that the observed effect size across individual studies varied to a degree greater than what would be expected due to chance and, as such, a random effects model was used to estimate the global effect. The estimate effect of gender on CRF was 1.072 with a 95% confidence interval between .838 and 1.307, $z = 8.96$, $p < .001$. These results indicate that there was a large effect of gender on CRF with males tending to have higher CRF than did females.

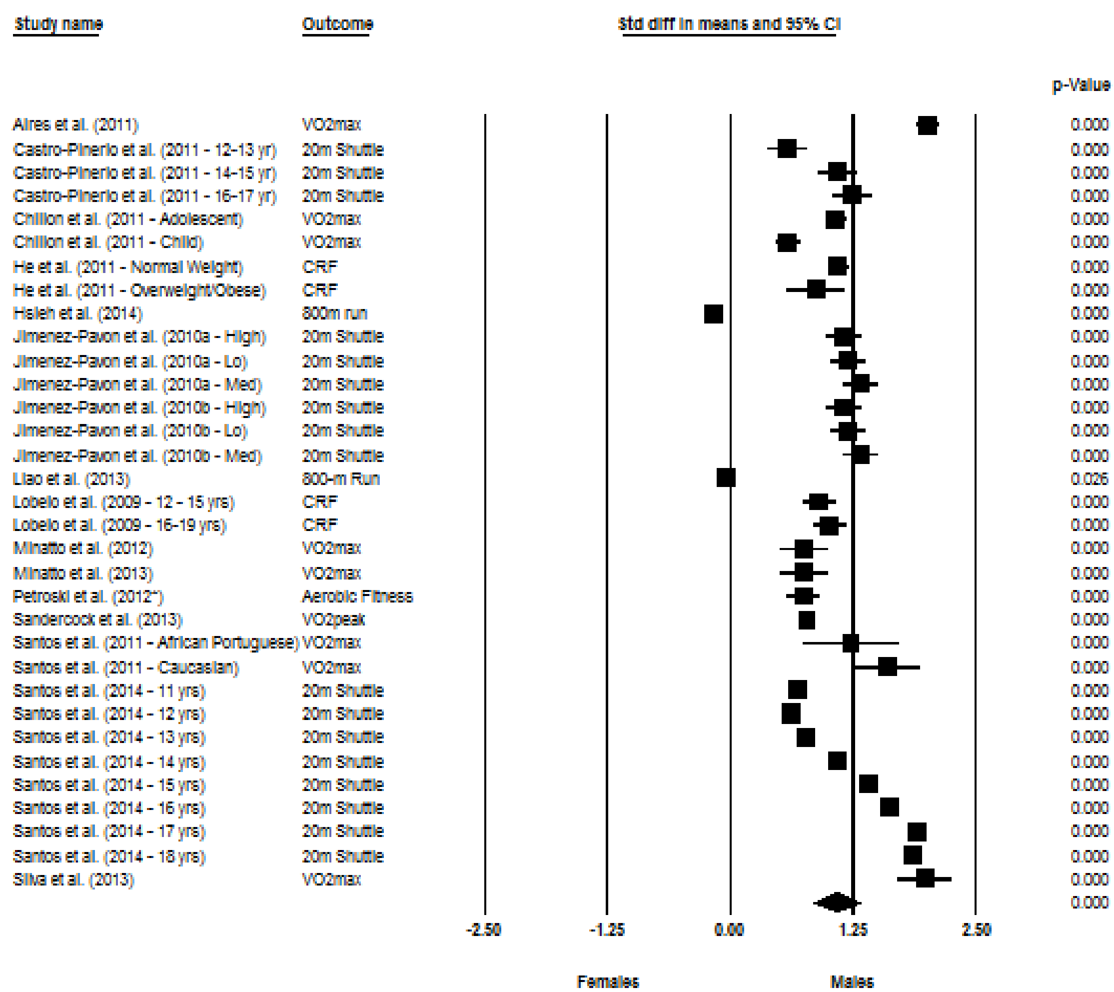

Figure 2. *Forest plot for CRF by gender.*

To examine the potential impact of study characteristics on the relationship between gender and CRF, additional meta-analyses were conducted using study characteristics as categorical moderators. First, the impact of study size was examined, see Figure 3. Examination of sample size revealed significant heterogeneity within each sample size group, indicating that there was greater variance across observed effect sizes within the sample group than would be expected, *ps* < .001. Using a Mixed Effects model to account for this observed heterogeneity, there was not a significant difference between estimated effect sizes across sample size, indicating that sample size did not appear to have a moderating effect on the relationship between gender and CRF, $p = .651$.

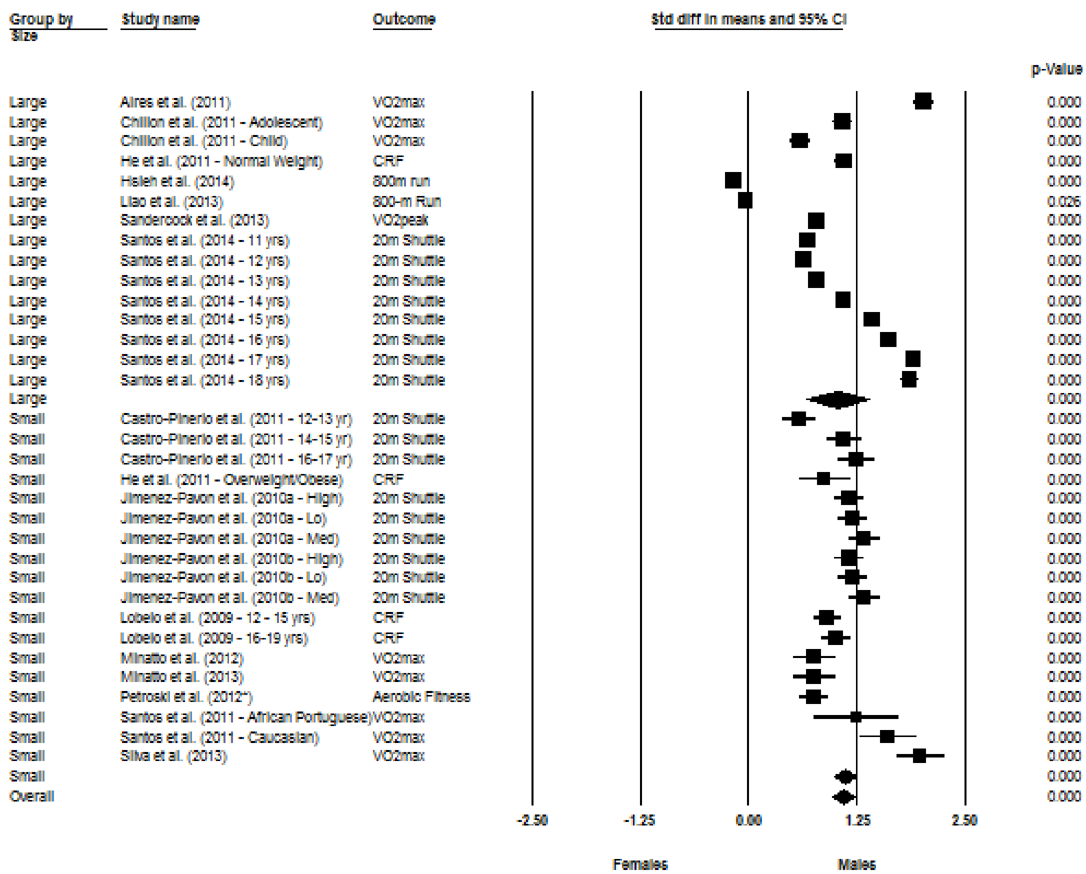

Figure 3. Forest plot for CRF by gender by sample size.

Next, the potential impact of country was examined, see Figure 4. There was more dispersion within studies than expected for the following countries/regions: Asia, Portugal, and Spain, all *p*s < .001. Utilizing a Mixed Effects model to account for the observed heterogeneity within studies, there was a significant difference in estimated effect size as a function of Country, $p < .001$. The greatest observed effect of gender on CRF was observed in studies from Portugal (1.636) followed by Spain (1.030) and the US (.955). The observed effect from Asian studies (.429) was not significant, $p = .105$. Overall, these findings suggest that there appears to be an effect of region or potentially ethnicity on the relationship between gender and CRF. These results should be interpreted with some caution due to the observed heterogeneity within studies in the same country and further research may be needed to further understand the impact of country on the relationship between gender and CRF. Additionally, there were limited observed effect sizes across some countries, particularly England ($k = 1$) and the US ($k = 2$), which may further limit the generalizability of these findings.

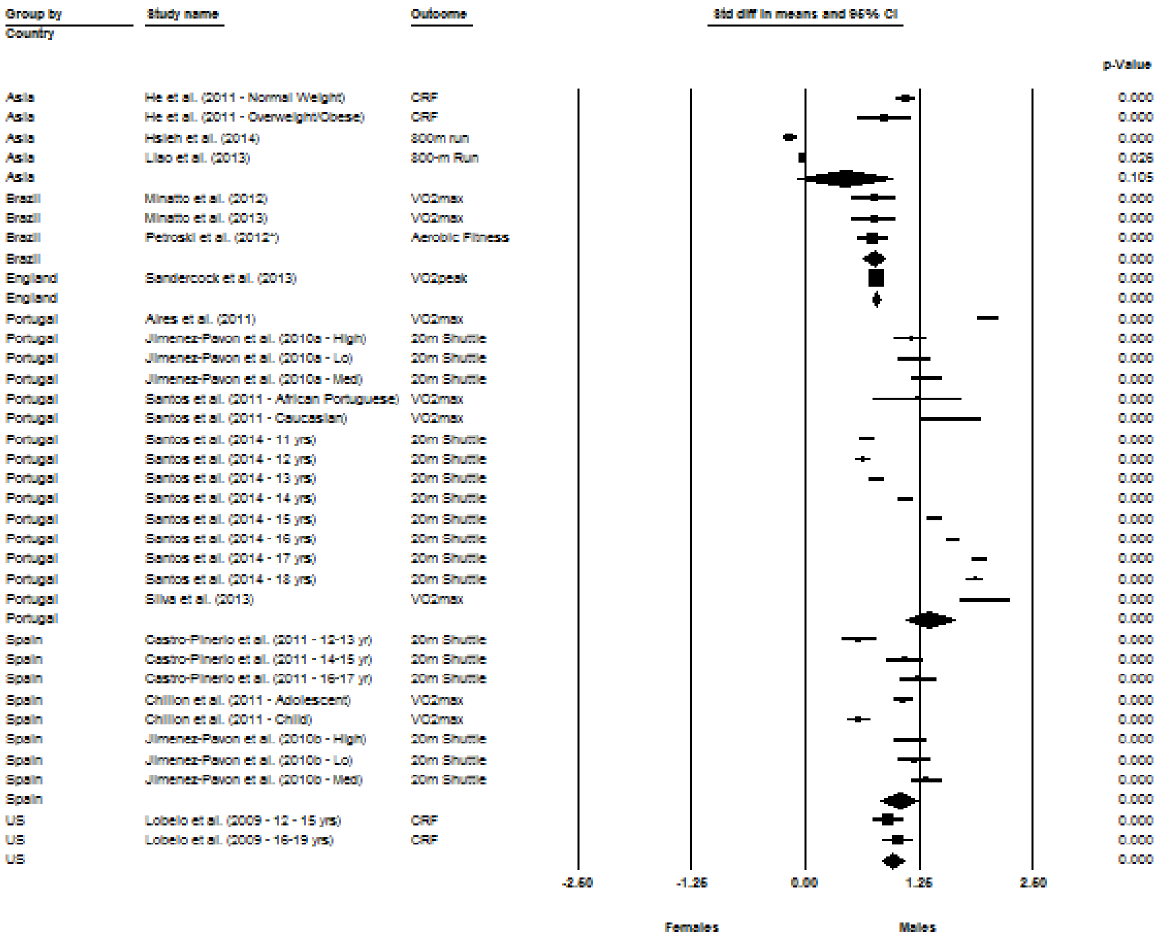

Figure 4. Forest plot for CRF by gender by study country.

The effect of study design is outlined in Figure 5. There was more dispersion within each group than would be expected due to chance, all *p*s < .001. Utilizing a Mixed Effects model to account for the observed heterogeneity within studies, there was not a significant difference between estimated effect sizes across study methods ($p = .937$), indicating that type of analysis used did not appear to have a moderating effect on the relationship between gender and CRF.

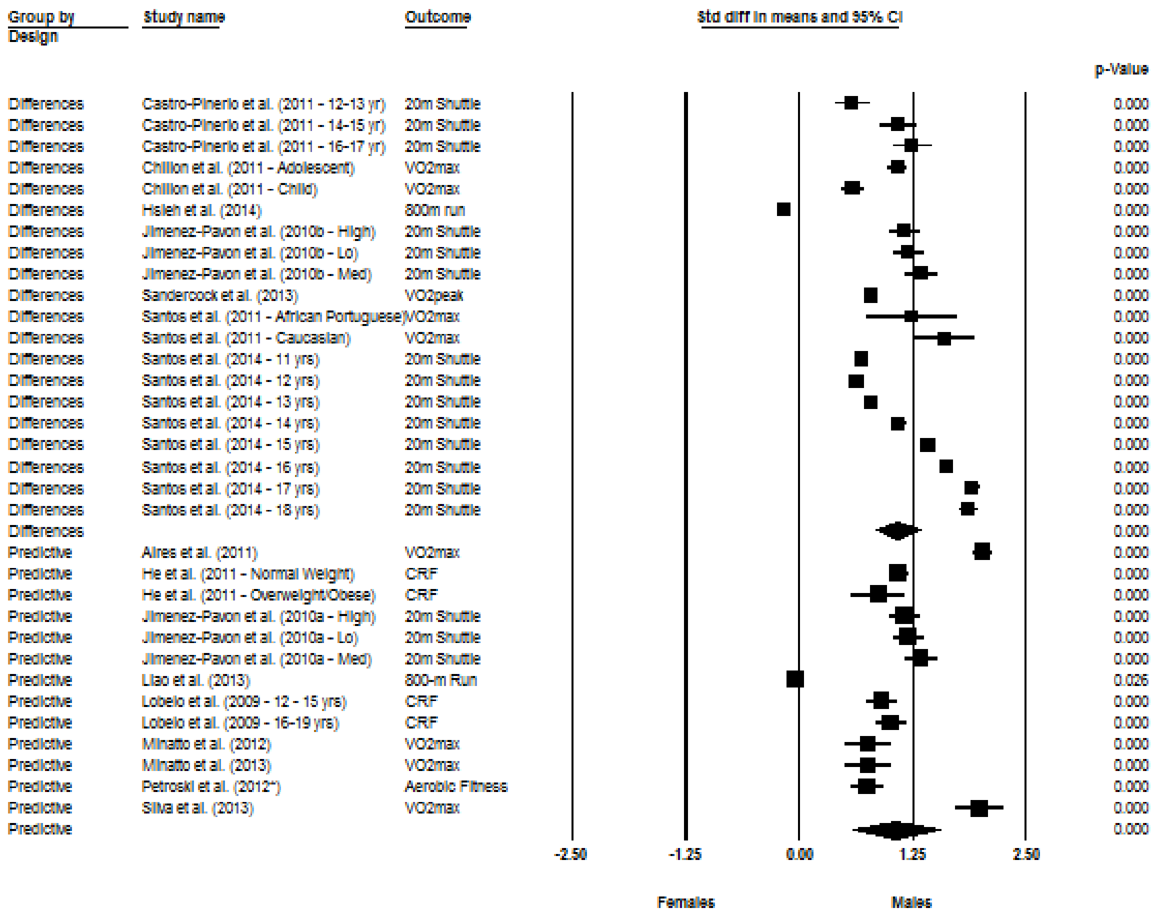

Figure 5. Forest plot for CRF by gender by study design.

The moderation analysis split by age is outlined in Figure 6. There was significant heterogeneity within studies of the same age classification, indicating that observed effect sizes in the same group differed to a degree greater than expected due to chance. The differences in effect size across age groups were examined using Mixed Effects model, indicating a significant difference in observed effect size as a function of age, $p < .001$. There was a stronger difference in CRF between males and females 16 years or older (1.535) than there was for those younger than 16 (.897). These results suggest that differences in CRF between males and females increase with age.

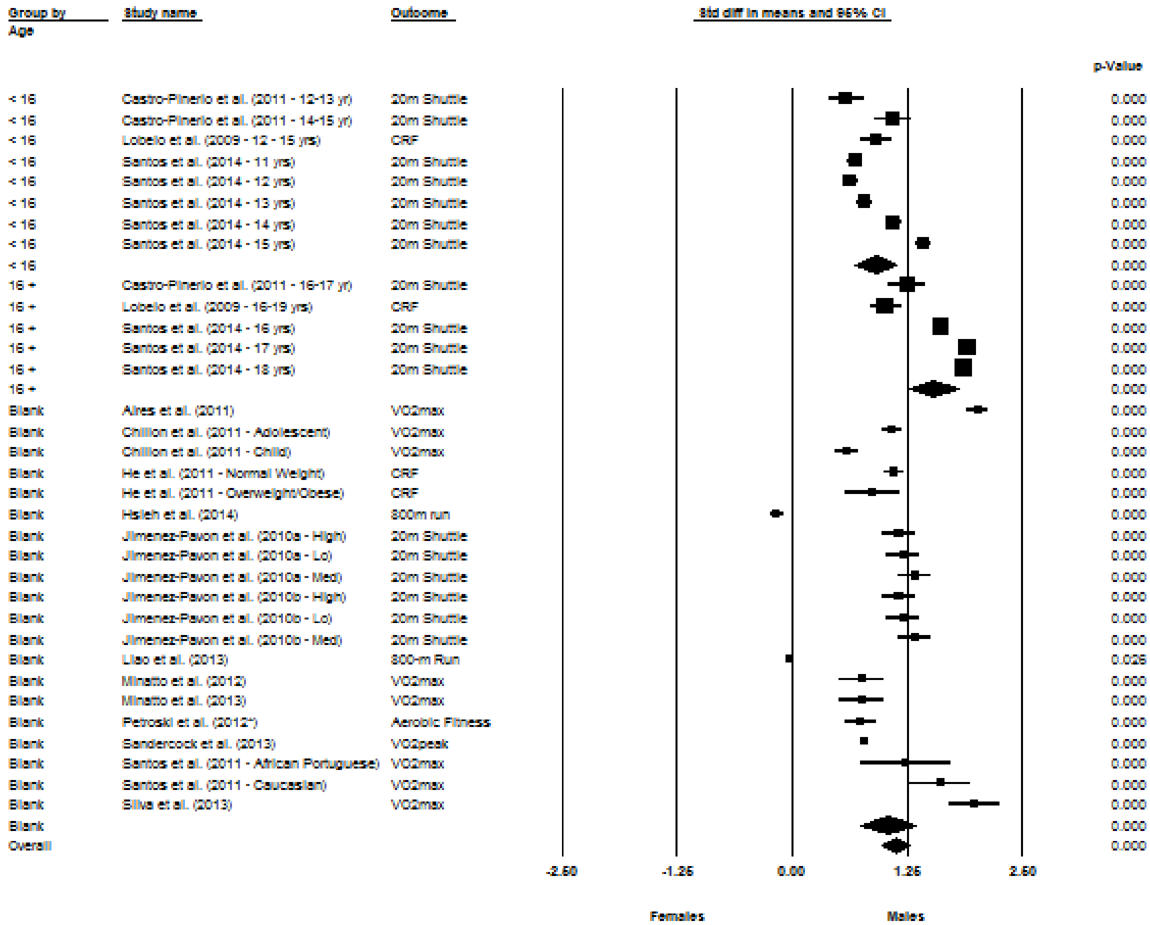

Figure 6. Forest plot for CRF by gender by age.

A summary of all analyses conducted on the impact of gender on CRF is outlined in Table 3. As shown, results consistently indicated that males had greater CRF than did females. The only non-significant effect observed was in Asian countries. While the magnitude of estimated effect sizes did appear to vary slightly as a function of country of study, observed effect sizes were in general large or approaching large, indicating that males had substantially greater CRF than did females.

Table 3

Summary of Meta-Analysis Findings for Gender

	K	ES	95% CI *LL*	95% CI *UL*	*p*	*Q*	*p*	I^2
All Effects	33	1.072	.838	1.307	< .001	5398.00	< .001	99.41
Sample Size								
Small	15	1.020	.655	1.385	< .001	5037.50	< .001	99.72
Large	18	1.110	.974	1.247	< .001	134.26	< .001	87.34
Total Between						.205	.651	
Country								
Asia	4	.429	-.089	.948	.105	448.56	< .001	99.33
Brazil	3	.749	.626	.872	< .001	.00	.997	.00
England	1	.782	.735	.829	< .001	.00	1.000	.00
Portugal	15	1.636	1.101	1.626	< .001	1207.77	< .001	98.84
Spain	8	1.030	.823	1.237	< .001	91.31	< .001	92.33
US	2	.955	.836	1.073	< .001	.70	.403	.00
Total Between						31.36	< .001	

Table 3, *continued*

Summary of Meta-Analysis Findings for SES

			95% CI					
	K	ES	*LL*	*UL*	*p*	*Q*	*p*	I^2
Design								
Tests of Difference	20	1.080	.835	1.325	< .001	2212.43	< .001	99.14
Predictive Analyses	13	1.059	.857	1.539	< .001	2044.91	< .001	99.41
Total Between						.01	.937	
Age								
< 16 Years	8	.897	.678	1.117	< .001	260.62	< .001	97.31
16 + Years	5	1.535	1.265	1.806	< .001	118.09	< .001	96.61
Total Between						12.90	< .001	

Potential publication bias was examined using a variety of techniques to assess whether or not observed effect sizes were skewed in a positive direction. A funnel plot was created (see Figure 7), and observed effect sizes were slightly biased towards positive findings. Rosenthal's Fail Safe N (Borenstein, 2005) was calculated, indicating that a total of 1640 missing studies would need to exist to shift the significance of the current findings. Duval and Tweedie's trim and fill approach (Borenstein, 2005) was utilized to examine the potential effect of missing studies on the overall findings of this meta-analysis. Results indicated that when assuming missing studies fall to the left of the mean the adjusted point estimate would be .746 with a 95% confidence interval between .729 and .763. Although there is some evidence that the results of the gender analyses were impacted slightly by publication bias, it is impossible to fully know to what degree.

Socioeconomic Status (SES)

Research Question 2 focused on the impact of SES on CRF. A meta-analysis was conducted to answer this research question. Examination of the heterogeneity of studies was substantial, Q (7) = 1176.55, $p < .001$, $I^2 = 99.41$, indicating that observed effect sizes differed across studies to a degree that was greater than would be expected due to chance. As such, the overall estimated effect was calculated using a random effects model (see Figure 8). Five of the observed effect sizes were significant, $p < .001$. All the significant effect sizes were in a negative direction, indicating that a lower SES was associated with poorer CRF compared to a higher SES. The overall estimated effect was -1.437 with a 95% confidence interval between -2.292 to -.581, $z = -3.29$, $p < .001$.

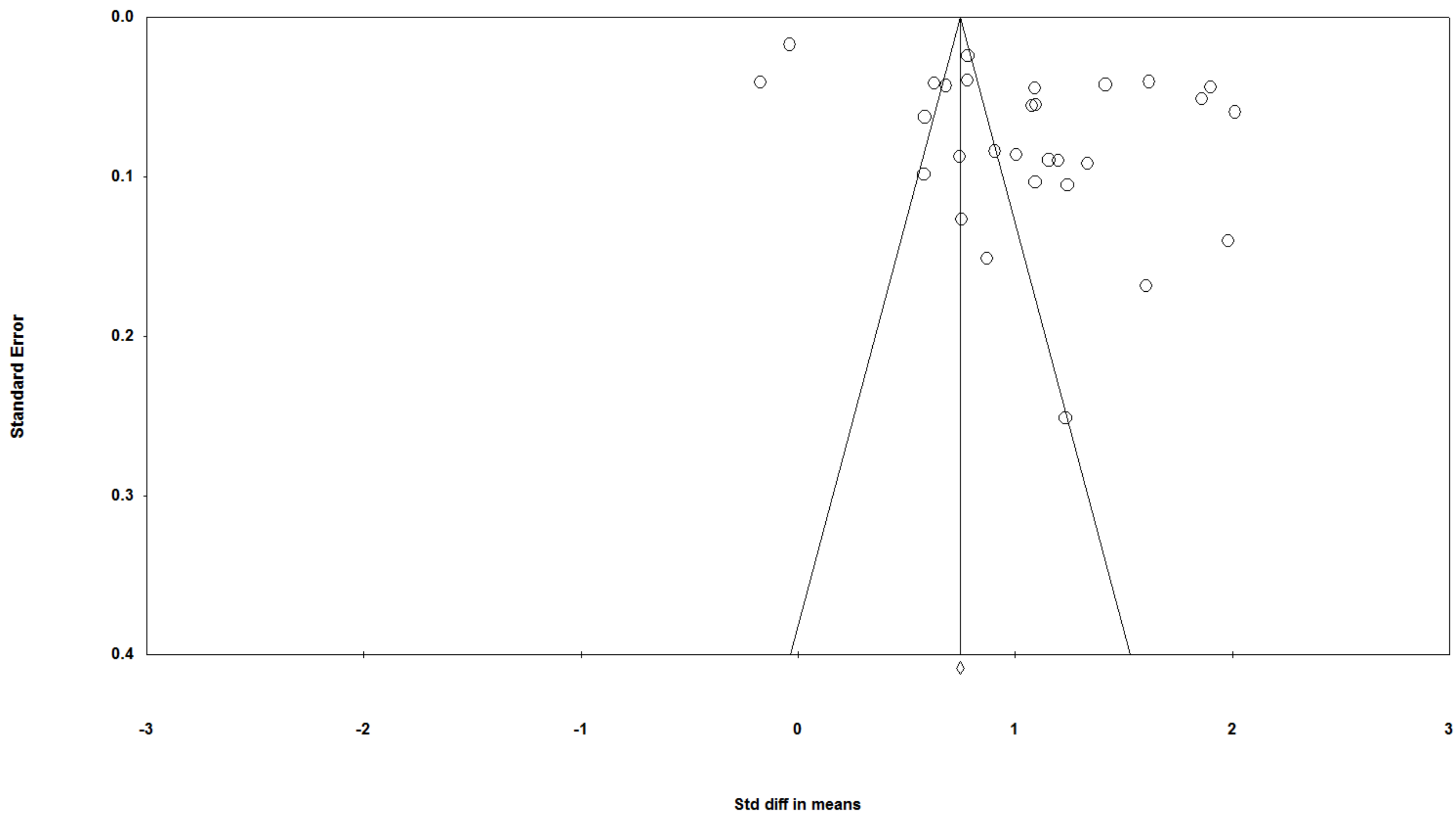

Figure 7. Funnel plot examining publication bias for gender studies.

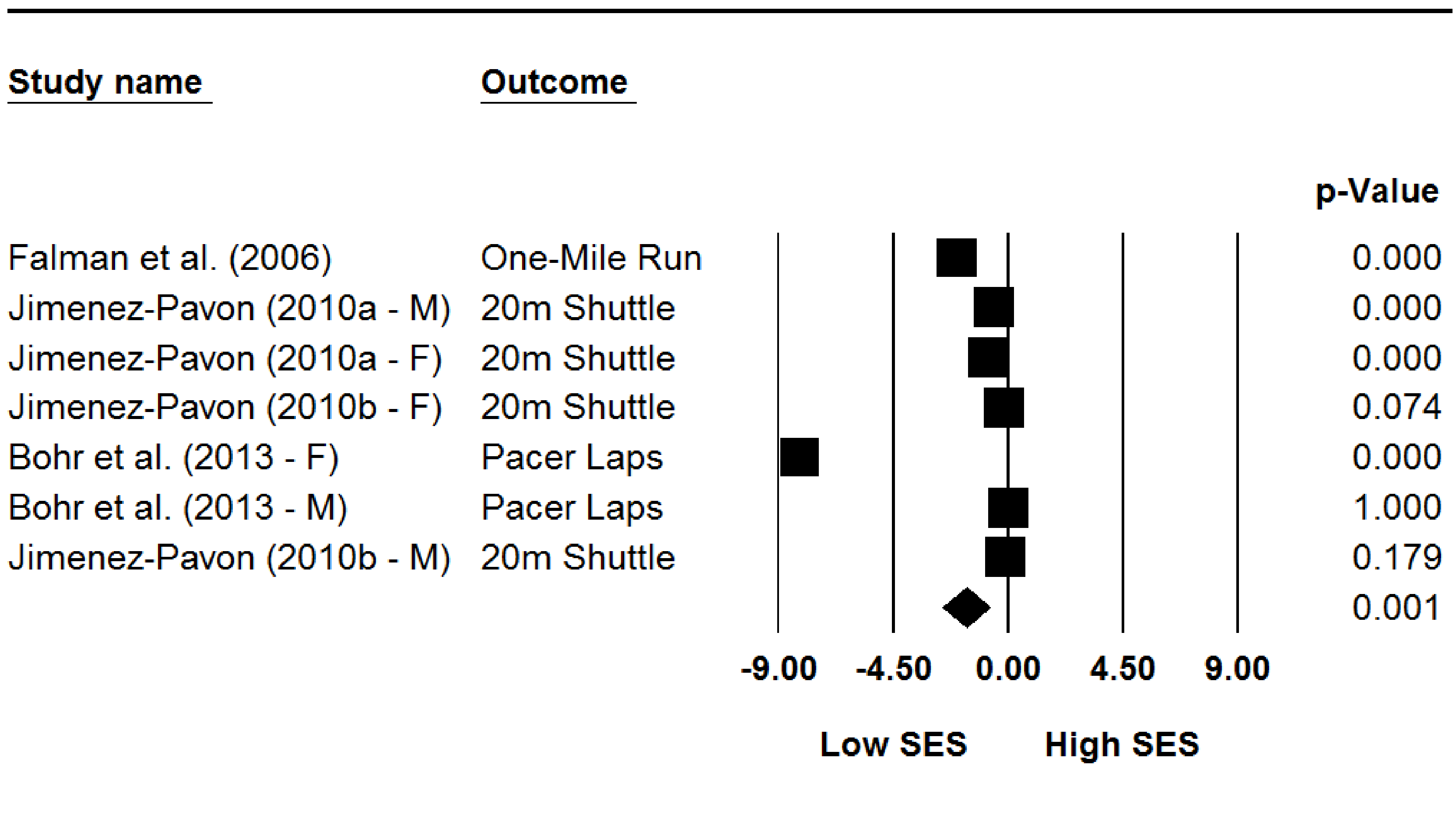

Figure 8. Forest plot for CRF by SES.

A series of moderating analyses were conducted to examine any potential effects of study characteristics on the relationship between SES and CRF. As shown in Figure 9, the effect by sample size had significant heterogeneity between studies of the same sample size, $p < .001$, indicating that observed effect sizes varied to a degree greater than what would be expected due to chance. Utilizing a Mixed Effects model to account for the observed heterogeneity between studies, there was not a significant difference between estimated effect sizes across sample size, $p = .161$, indicating that sample size did not appear to have a moderating effect on the relationship between SES and CRF. When split by sample size, the observed effect size for each group approached significance, $p < .10$, which is likely a function of limited number of studies in the analysis. Overall, these analyses suggest that there does not appear to be an effect of sample size on the findings of this meta-analysis. Across sample sizes, there appears to be a strong relationship between SES and CRF with those in low SES having poorer CRF than did those of high SES.

Further moderation analyses were conducted to test the impact of country on the relationship between SES and CRF. Due to limitations of observed studies, only studies from Spain ($k = 4$) and the US ($k = 3$) were included in the analysis. There was significant heterogeneity across studies from Spain, $p < .001$, but not for studies from the US, $p = .403$, see Figure 10. Utilizing a fixed effects model, there was a significant difference in the estimated ES between the US and Spain, with the estimated ES for the US being much higher than for Spain. This suggests there is a greater difference in CRF across SES levels in the US than in Spain. Due to limited number of effect sizes and countries represented, these results should be interpreted with some caution, and further research may be needed to fully explore the moderating relationship that country has on the relationship between SES and CRF.

A summary of the analyses conducted on the relationship between SES and CRF is outlined in Table 4. Overall, there appears to be a strong effect of having a low SES on lower CRF when compared to having a high SES. This effect may be particularly present in the US compared to Spain. The results of these analyses should be interpreted with some caution, however, due to the limited number of effect sizes available, especially in moderation analyses. As such, further large-scale studies may be needed in order to determine the exact magnitude of the relationship between SES and CRF.

Potential publication bias was examined using a variety of techniques in order to assess whether or not observed effect sizes were skewed in a positive direction. A funnel plot was created (see Figure 11). As shown in the funnel plot, observed effect sizes were slightly biased towards positive findings. However, Rosenthal's Fail Safe N (Borenstein, 2005) was calculated, indicating that a total of 1521 missing studies would need to exist in order to shift the significance of the current findings. Lastly, Duval and Tweedie's trim and fill approach (Borenstein, 2005) was utilized to examine the potential effect of missing studies on the overall findings of this meta-analysis. Results indicated that when assuming missing studies fall to the right of the mean, the adjusted point estimate would be -.878 with a 95% confidence interval between -.945 and .811. While there is some evidence that the results of the gender analyses were impacted slightly by publication bias, it is impossible to fully know to what degree.

Summary

Results from this study found that there was consistently a strong relationship between gender and CRF with males appearing to have greater CRF than did females. While there were some differences in the magnitude of this relationship, this pattern was consistently found across sample sizes, study design, age, and country of origin, with the one exception of there being a non-significant effect for studies from Asian countries. Results also indicated a significant effect of SES on CRF, with those from a low SES being associated with lower CRF than were those from higher SES. Due to the limited number of effect sizes, moderation analyses were limited; however, this relationship does appear to remain constant regardless of sample size and country of study. The following chapter will discuss the implications of this study as well as limitations and suggestions for future research.

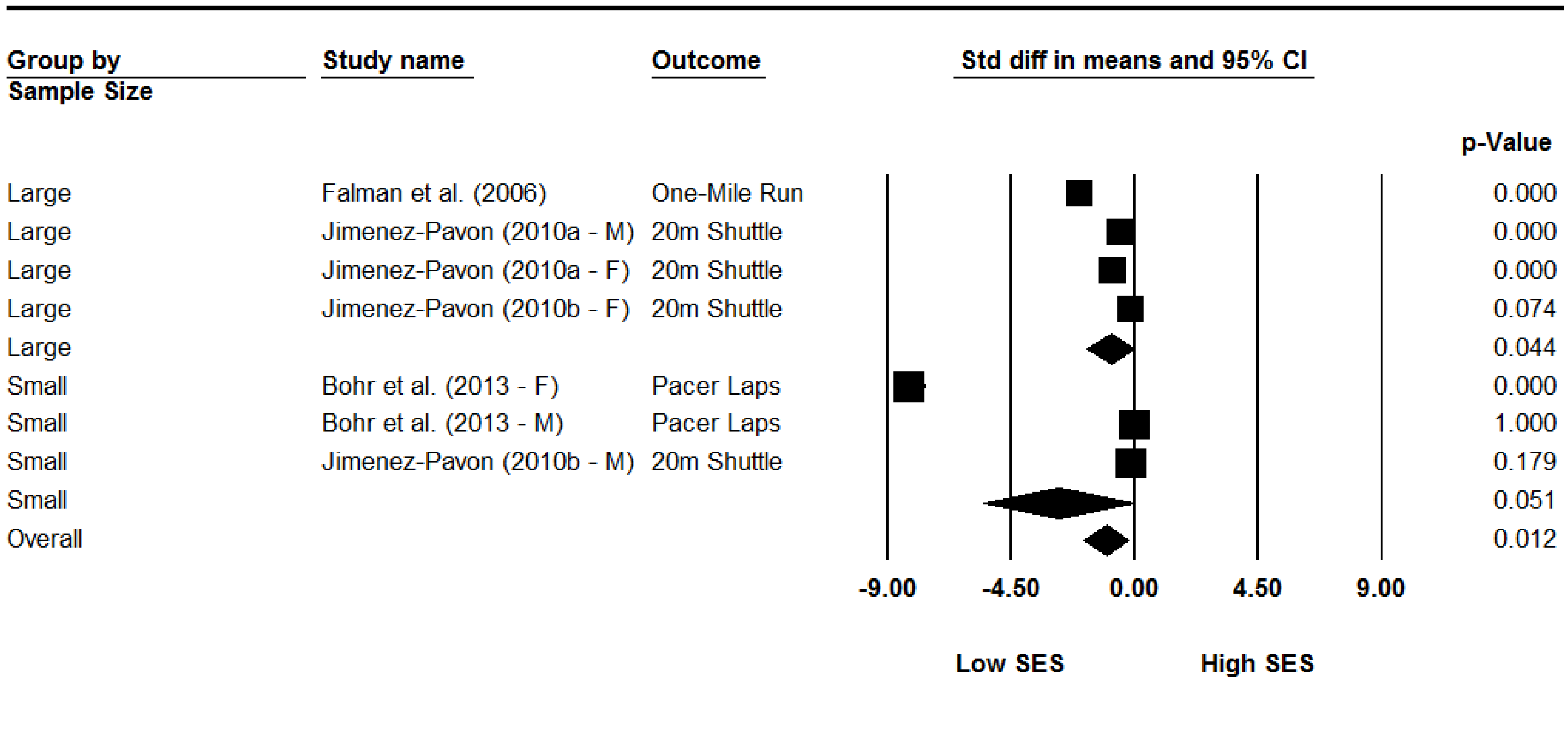

Figure 9. Forest plot for CRF by SES by sample size.

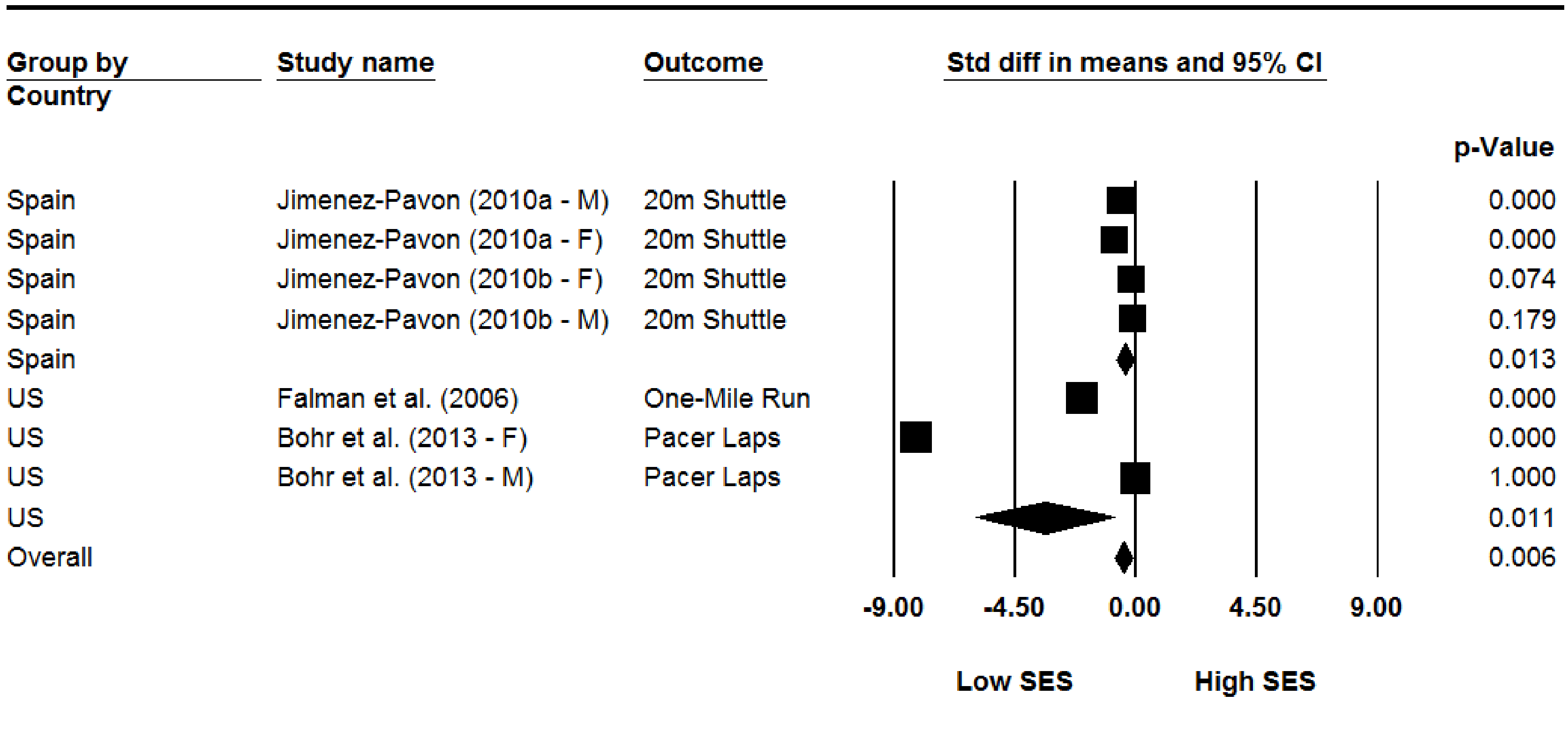

Figure 10. Forest plot for CRF by SES by country.

Table 4

Summary of Meta-Analysis Findings for SES

	K	ES	95% CI *LL*	95% CI *UL*	*p*	*Q*	*p*	I^2
All Effects	8	-1.437	-2.292	-.581	.001	1176.55	< .001	99.41
Sample Size								
Small	5	.388	-1.465	.058	< .001	401.90	< .001	99.01
Large	3	1.400	-5.496	.006	< .001	739.47	< .001	99.73
Total Between						1.97	.161	
Country								
Spain	4	-.402	-.720	-.085	.013	91.31	< .001	92.33
US	3	-3.370	-5.952	-.787	.001	.70	.403	.00
Total Between						4.99	.025	

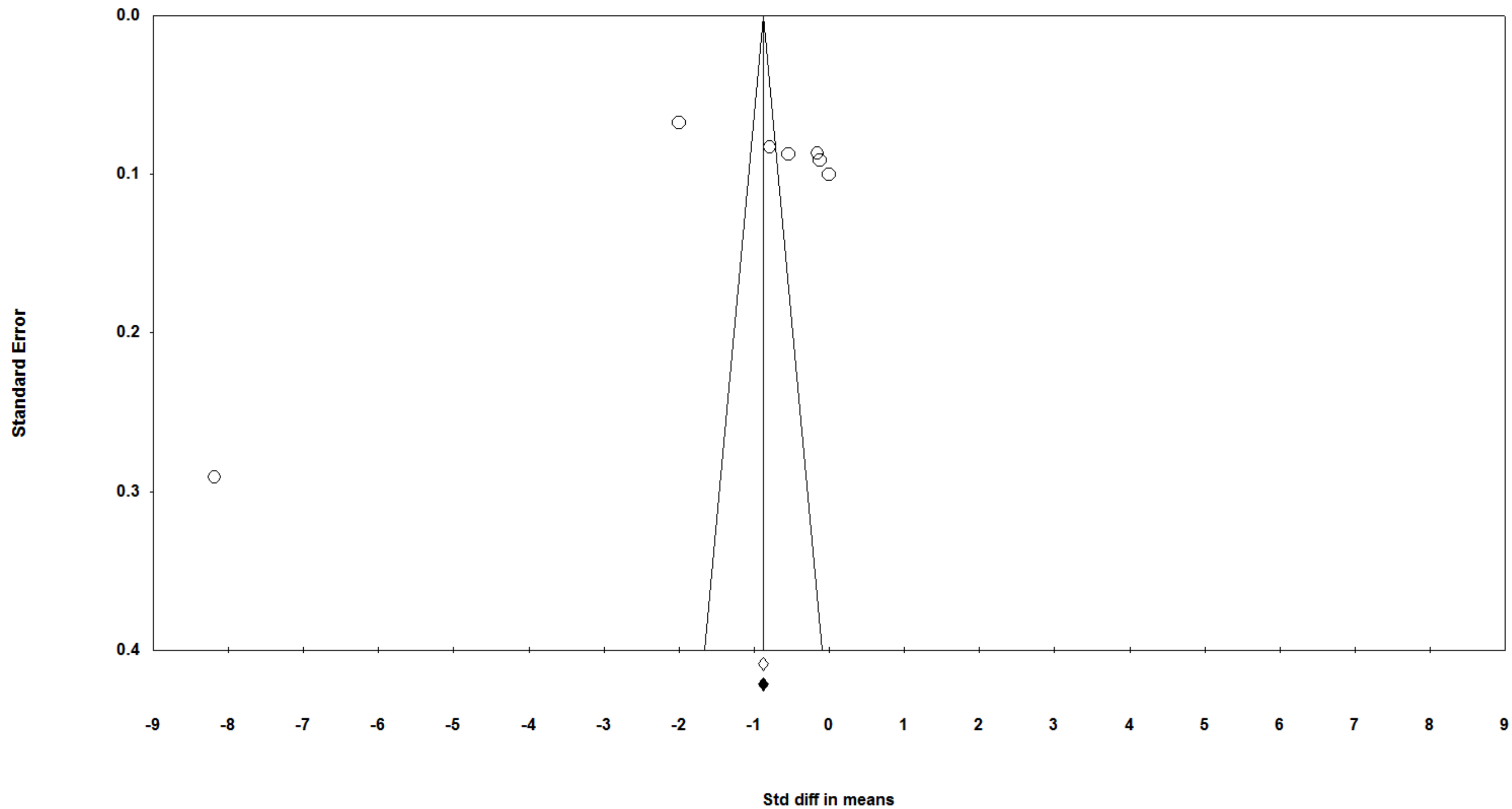

Figure 11. Funnel plot examining publication bias for SES studies.

Chapter 5: Discussion, Conclusion, and Recommendation

Introduction

The purpose of this investigation was to examine the association of gender and SEP on CRF in adolescents. Metabolic disease (e.g., metabolic syndrome) has become more prevalent in adolescents due to low CRF and inactivity (Neto et al., 2011). As such, researchers have proposed that certain sociodemographic variables may play a role in this occurrence. Factors, such as gender and SEP, may affect low CRF of adolescents, which, in turn, may predict poor cardiometabolic health in the future (Ortega, Ruiz, Castillo, & Sjöström, 2008). Primary studies have examined the effect of each factor on CRF. This meta-analysis sought to summarize the effects of gender and SEP on CRF. The additional task of examining potential moderators was also performed. A concise summary of key findings, interpretation of the findings, study limitations, recommendations, implications, and a conclusion are presented in this chapter.

Summary of Key Findings

Results from this study indicated a consistently strong relationship between gender and CRF because males appeared to have greater CRF than did females. Some differences existed in the magnitude of this relationship, but this pattern was consistently found across sample sizes, study design, age, and country of origin; the exception was a nonsignificant effect for studies from Asian countries. Results also indicated a significant effect of SES on CRF: Those from a low SES were more associated with lower CRF than were those from higher SES. Due to the limited number of effect sizes, moderation analyses were also limited; however, this relationship does appear to remain constant, regardless of sample size and country of study.

Interpretation of Findings

This meta-analysis appears to support what is currently known about the association of gender and CRF and extends what is currently known about the impact of SEP on CRF. Both gender and SEP showed an association with CRF. Due to the large number of studies obtained and large sample sizes, it is likely that the estimates obtained in this study are reflective of actual differences in the population of interest.

Research Question 1: Gender and CRF

Research Question 1 sought to answer the following question: Is gender associated with cardiorespiratory fitness in adolescents?

This meta-analysis found that gender is strongly associated with CRF in adolescents. Males tended to have greater CRF than did females. The overall size effect for gender was 1.072 (95% CI: .838–1.307, $p < .001$). Based on the Cohen's *d* interpretation (Cohen, 1988; Field & Gillett, 2010), this would be considered a large effect size, which was consistent with the majority of the studies reported in this meta-analysis. All but two of the studies (Hsieh et al., 2014; Liao et al., 2013) had a positive size effect, which suggests that males tend to have greater CRF than do females.

Of the 33 studies examined in this meta-analysis, 31 studies had medium-to-large effect sizes (.530 to 2.012). Overall, these results aligned with reports that included gender differences in CRF. For example, Pate and Kriska (1984) stated that males tend to have higher levels of CRF than do females. Furthermore, Pate et al. (2006) assessed the CRF level of a representative sample of 3,287 U.S. adolescents (12 to 19 years of age) and found that males have greater mean VO_2 max levels (46.0 ± 0.4 SEM) than do females (38.7 ± 0.3 SEM; Cohen's *d* = .533). Overall, it appears that differences in gender may be associated with male adolescents having higher CRF levels than do females. Many factors related to these differences are unknown, but physiological factors and the scaled measurement of CRF (VO_2 max) may explain differences between CRF levels in males and females.

Pate and Kriska (1984) stated that physiological differences could explain some of the differences between CRF in males and females. Proposed factors include bodyweight and body composition, hemoglobin concentration (Hb), and the maximum oxygen transport system (Pate & Kriska, 1984; Krahenbuhl, Skinner, & Kohrt, 1985; Keller, 2008). Pate and Kriska suggested that gender differences related to CRF can be accounted for by differences in "cardiovascular dimensions, blood constituents, body size, and body composition" (p. 91). For example, VO_2 max expressed in absolute terms (ml O_2/min) explains 50% of the variance between males' and females' aerobic power; however, when aerobic power is expressed relative to bodyweight (ml O_2/kg/min), differences decrease by 15% to 30% in trained and untrained males and females (Pate & Kriska, 1984; Charkoudian & Joyner, 2004). Charkoudian and Joyner (2004) reported that even when males and females are matched based on age, height, and lean muscle mass, significant gender differences in VO_2 max still persist.

Similar to Charkoudian and Joyner (2004), Dencker et al. (2006) and McMurray, Hosick, and Bugge (2011) found that significant between-gender differences still existed when all other scales were used to measure VO_2 max (*p*s < 0.001). The literature proposed physiological explanations for this phenomenon. VO_2 max is a product of maximum cardiac output (maximum heart rate × maximum stroke volume) and maximum arteriovenous oxygen difference. Maximum heart rate (HR_{max}) is the maximum heart beats per minute, but maximum stroke volume (SV_{max}) is the maximum amount of oxygenated blood that can be pumped from the left ventricle with each beat. Females tend to have smaller body sizes compared to men, which generally results in smaller blood volume in females (Charkoudian & Joyner, 2004). Smaller blood volume results in lower circulating hemoglobin to transport the oxygen to the working muscles (Charkoudian & Joyner, 2004). Females also have lower resting stroke volume levels than do men, which results in a lower amount of oxygenated blood being pumped from the left ventricle at any intensity level (Charkoudian & Joyner, 2004). Therefore, females tend to have lower VO_2 max whether measured in absolute or relative terms.

Correcting for fat-free mass does not completely eliminate gender differences (Charkoudian & Joyner, 2004). This was evident in Dencker et al. (2006) and McMurray et al. (2011). Dencker et al. examined whether gender differences would occur in CRF (peak VO_2 max) in children who were 8 to 11 years old, and they used various ratio and allometric scaling models to examine peak VO_2 max. Dencker et al. found that both ratio and allometric scaling models yielded statistically significant gender differences in peak

VO_2 (ps < 0.001). Multiple regression analyses indicated that when peak VO_2 max was measured relative to either body mass or lean body mass, gender was still a significant predictor (64% and 58% of the variance, respectively; ps < 0.001). Interestingly, McMurray et al. (2011) collected data to examine the significance of proper scaling of aerobic power predicting cardiometabolic risk factors in youths, and 6 different scaled VO_2 max were used to assess CRF. Regardless of the scale used, females tended to have lower VO_2 max compared to males (ps < 0.001) with VO_2 max ($mL/kg_{FFM}/min$) having the smallest average mean between boys and girls. Based on the studies reviewed for this meta-analysis, relative VO_2 (ml/kg/min) was used to determine CRF. However, using alternative scaling methods (e.g., fat-free mass, allometric scaling) may decrease gender differences. Overall, this suggests that the scaling index used to assess CRF is inconclusive and that further research is needed to investigate new scaling indexes that may further reduce gender differences in CRF. It is possible that the use of other scaling methods could reduce these gender differences.

Overall, it appears that females have lower resting stroke volumes compared to males. As such, females tend to pump less blood from the heart per beat than do males (Charkoudian & Joyner, 2004). These physiologic processes may contribute to the observed VO_2 max differences between males and females, regardless of the scaled measure (Charkoudian & Joyner, 2004); however, examining these processes is beyond the scope of this meta-analysis. Physiologic processes could help to account for some of the gender differences in VO_2 max, but other variables were examined to ascertain whether they moderated the association between gender and CRF.

As mentioned earlier in this discussion, the homogeneity tests indicated that the heterogeneity across studies were greater than what would be expected, due to chance; therefore, I sought to investigate study characteristics that could explain these differences. Sample size, study design, age, and country (categorical moderators) were assessed to determine their impact on the association between gender and CRF.

Sample size was examined because some researchers suggested that meta-analyses tend to rely on all available evidence that meet the prespecified eligibility criteria, with sample size being assessed secondarily (Turner et al., 2010). It was also apparent from visual inspection that this may explain some of the variance; more specifically, I was concerned about the small study effect. The small study effect is a bias in which small studies tend to report greater size effects than do larger studies (Turner et al., 2013). The groups were coded categorically as small (< 1,000) and large (> 1,000) samples. The results showed greater variability in the effect sizes within each sample group than would be expected, due to chance; however, when a mixed effects model was used, the variability within these sample groups subsided. On the other hand, when examining the effect sizes for the small group and the large group, both groups had relatively large effect sizes and any variability (based on the use of the fixed effects model), due to chance. Based on the aforementioned results, it appears that sample size did not impact the association between gender and CRF.

Study design was also examined to determine its impact on the association between gender and CRF because, as Littell et al. (2008) stated, study design could influence variations in effect sizes. The two types of studies examined in this meta-analysis were tests of difference and predictive analyses. Moderation analyses revealed that the types of analysis did not appear to have a moderating effect on the relationship between gender and CRF.

Age appeared to be a moderator between gender and CRF. Older adolescents (16+ years of age) tended to exhibit a stronger effect size between girls and boys than did those younger than 16 years old. Evidence substantiates that age may be a moderator that impacts the association between gender and CRF. Pate et al. (2006) found that estimated VO_2 max was significantly lower in 12- and 13-year-old boys than it was in older boys; in girls, the opposite was true. On the other hand, Ribeiro et al. (2013) found that CRF (estimated VO_2 max) tended to be significantly lower with increasing age groups. For example, 16- and 17-year-old youths had estimated VO_2 max that were significantly lower than 11 to 15 year olds ($p < 0.05$). Knowing how age impacts CRF is one possible explanation, using criterion-referenced fitness tests (e.g., FITNESSGRAM®) that have standards that are age and gender specific (Meredith & Welk, 2004). Another consideration when examining age as a moderator is the interaction of biological maturation and chronological age (Cummings, Standage, Gillison, & Malina, 2008; Ortega, Ruiz, Castillo, Moreno, et al., 2008). An examination of the physiological, body mass, and body fat changes that occur during the adolescent period are indicators of the effect of age and biological maturation. Based on the results of this meta-analysis, it appears that age, as suggested in the physical fitness measures, and the health outcomes conceptual model could be potential moderators of the relationship between gender and CRF outcomes; however, more research may be warranted in this area.

The country where the study was conducted was also examined as a potential moderator between gender and CRF. Overall, there appeared to be an effect region of ethnicity on the relationship between gender and CRF. Large effect sizes were noted for Portugal (d = 1.636), Spain (d = 1.030), and the US (d = .955). It is also worth mentioning that all of these studies found similar findings (i.e., males had greater CRF than did females); however, the magnitude of these relationships differed. This was slightly different than the other potential moderator possibilities, such as the differences in direction or nonsignificant observed effect. A surprising finding was the nonsignificant effect sizes for studies conducted in Asian countries. These results should be interpreted cautiously due to limited studies in other countries sampled in this meta-analysis, but it is plausible that the differences between genders are real. One reason for these large size effects could be the number of studies and the positive results of the studies from each of these countries.

Vickers, Goyal, Harland, and Rees (1998) stated that the impact of country when conducting a systematic review or meta-analysis is justified because higher proportions of studies that come from one country or geographic location may increase the proportions of positive results. Vickers et al. discussed the higher proportion of studies with positive findings that could moderate the effects between an independent variable and an outcome, but it is also plausible that seasonal variations between and within these geographic locations may explain the gender differences in CRF. Reports have suggested that seasonal variations in different geographic locations could impact aerobic fitness due to physiological adaptive processes (Simpson, 2010) and changes in physical activity (Bélanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009). Moreover, Simpson (2010) concluded that aerobic fitness variations between studies from different locations are related to the specific study; however, this was only a literature review and not a meta-analytic study to parcel out the effect sizes of geographic and seasonal variations with CRF. Furthermore, Simpson's review did not include a gender stratification analysis to determine if gender differences existed.

Bélanger et al. (2009) performed a cross-sectional analysis to examine the interaction between physical activity level, season, and weather on 1,293 youths aged 12 to 13 years old. After controlling for age, sex, and month, physical activity decreased with increasing rainfall but increased with an increase in temperature. Snowfall led to decreased physical activity during the winter season but increased during the warmer months (Bélanger et al., 2009). Only speculations are possible, but it is plausible that female physiology, the environment, and lowered physical activity all interact, which could potentially lead to gender differences. More research is needed to determine the links among these factors.

As with any meta-analytic study, publication bias was examined. Visual inspection of the funnel plot revealed slight bias in a positive direction. However, the calculated Fail Safe *N* test indicated that 1,640 studies would need to shift the significance to null. Based on Rosenthal's ad hoc rule of thumb (Ellis, 2010), when the Fail Safe *N* is large (as it is in this case), relative to the number of studies in the meta-analysis (*k*), the results tend to be robust to publication bias (Ellis, 2010). Based on this criterion, the number exceeded 175 ($5k + 10$; Ellis, 2010); therefore, the result appears to be robust.

To further adjust for bias, the Duval and Tweedie's trim and fill procedure (Borenstein, 2005) was calculated. The adjustment of potential missing studies still yielded a relatively large effect size ($d = .746$; 95% CI: .729–.763). The evidence has suggested some degree of publication bias, but it is impossible to fully know to what degree. In the next section, I discuss the interpretation of findings for the association between SEP and CRF.

Overall, it appears that gender is associated with CRF, in that males have greater CRF than do females. This result suggests that age (as indicated in the physical fitness measures and health outcomes conceptual model) may moderate the association between gender and CRF and that this relationship appeared to be stronger in older adolescents than it did in younger adolescents. Sample size and study design did not appear to moderate the association between gender and CRF.

Research Question 2: SEP and CRF

Research Question 2 sought to answer the following question: Is socioeconomic position associated with cardiorespiratory fitness in adolescents?

A meta-analysis was conducted to analyze the association between SEP and CRF in adolescents. This study concluded (based on the limited studies that were retrieved related to SEP and CRF) that SEP (SES) had a significant effect on CRF: Those with a lower SEP also had lower CRF, compared to those who had higher SEPs. These observed effect sizes appeared to differ significantly across studies greater than would be expected, due to chance. Due to the limited number of studies and the limited information concerning other possible moderators, moderation analyses were conducted for sample size and country. Sample size did not appear to have a moderating effect on the relationship between SEP and CRF.

Moderation analyses were conducted to examine if the country moderated the effect between SEP and CRF. The results revealed significant heterogeneity across studies in Spain but not across studies in the US. Significant differences were noted in the size effects between Spain and the US, with the effect size being higher in the US than it was in Spain. This suggests larger differences in CRF across studies in the US than across studies in Spain. One plausible explanation for the differences in the results of studies conducted in Spain may be due to the different instruments used and the scaling of each instrument used to measure SEP. For example, Jiménez-Pavón, Ortega, Ruiz, España Romero, et al. (2010) used parental education levels to measure SEP, and Jiménez-Pavón, Ortega, Ruiz, Chillón, et al. (2010) used the Family Affluence Scale to assess SEP. With that in mind, it seems plausible that the differences in the Spanish studies were due to the methods used to assess SEP. On the other hand, the limited studies from the US assessed SEP by determining whether students qualified for free or reduced lunch.

Utilizing the same measure in the US yielded similar results compared to the results in the Spanish studies that used different measures. Another plausible explanation is that Spain may have less economic disparities than the US does. The *Credit Suisse Global Wealth Handbook* reports greater wealth concentration in the US (75.4%) compared with countries like Spain (54%; Shorrocks, Davies, & Lluberas, 2013). The Organization for Economic Co-operation and Development (OECD) reports a ratio called the Gini coefficient, which is considered the broadest quantitative measure of wealth inequality. A score of 0 indicates perfect wealth distribution, but scores that approach 1 indicate greater concentration of wealth (OECD, n. d.). Overall, the data showed that from 1996 to 2011, Spain had less income inequality (Gini coefficient) and lower income poverty, relative to the US (OECD, n. d.). Therefore, the economic climate in Spain could potentially explain the differences found between Spain and the US.

This interpretation must be approached cautiously, however, because similar results using the same measure may not be synonymous using a measure that is capable of assessing the overall construct of SEP. There is little agreement about the best way to measure SEP (Braveman et al., 2010) because it is difficult to measure and can interact with gender, race/ethnicity, and environmental factors to produce differential health outcomes across groups (Braveman et al., 2010). An example of this appears to be true when we examine the differences between males and females in the Bohr et al. (2013) study. Due to the limited studies found in this meta-analysis, large scale studies are warranted to examine the exact magnitude of the relationship between SEP and CRF. Also, more studies should be conducted to determine methods to measure the totality of SEP and, if possible, determine the interactions of SES with other possible moderators of CRF.

As discussed in the aforementioned section, limited studies were retrieved for this meta-analysis; therefore, publication bias was assessed utilizing multiple techniques. The results of the funnel plot revealed that the magnitude of SEP's effect on CRF was in a positive direction, indicating that SEP appeared to be strongly associated with SRF. This finding suggests a slight bias that may have occurred due to limited studies. However, Rosenthal's failsafe *N* calculation indicated that over 1,500 studies would be needed to create a null effect. Based on Rosenthal's ad hoc rule of thumb (5k + 10), this meta-analysis would need 50 studies to reverse the direction towards the null (Ellis, 2010). The number of studies with null findings that needed to exceed this number was greater than the ad hoc number, indicating robust findings; however, it is impossible to truly know to what degree publication bias exists.

Overall, these results indicate that SEP was associated with CRF and that country of origin may be a moderator between SEP and CRF (thus, supporting the conceptual framework that SEP is related to CRF). The differences in outcomes between the Spain and U.S. studies may be due to different instruments used to measure SEP or a better economic climate. With this in mind, more studies are warranted to investigate these differences.

In summary, the results from this study found a consistent, strong relationship between gender and CRF, and males appeared to have greater CRF than did females. Some differences existed in the magnitude of this relationship, but this pattern was consistently found across sample sizes, study design, age, and country of origin; the one exception was a non-significant effect for studies from Asian countries. Results also indicated a significant effect of SES on CRF; those from a low SES were associated with lower CRF than were those from higher SES. Due to the limited number of effect sizes, moderation analyses were limited; however, this relationship does appear to remain constant, regardless of sample size and country of study.

Study Limitations

As is the case with all research, this study was not without its limitations. First, cross-sectional studies cannot confer cause and effect; however, the nature of the research questions made cross-sectional studies appropriate for this meta-analysis. Second, publication bias (as seen in the funnel plot) was my greatest concern, due to limited studies retrieved for this meta-analysis. This could imply that there were missing studies in this investigation, and it may be true, given missing non-English language, SEP, and other unpublished studies. On the other hand, the Rosenthal's failsafe *N* and Duval and Tweedie's trim and fill calculations (Borenstein, 2005) suggested that the results were robust in each case. With this in mind, it is not possible to know if the results of this study are absolute until more studies are conducted to determine the association between gender, SEP, and CRF. The results of this study must be interpreted with caution.

Also, the results are limited to the population, settings, and context in which they were investigated. Steckler and McLeroy (2008) stated that "systematic reviews and meta-analyses are limited in the conclusions that can be drawn when external validity data are not reported" (p. 10). This meta-analysis examined gender (males/females), age (adolescents), and country as potential moderators. Therefore, the results may only be applicable to adolescent males and females in the countries where these studies took place. It is plausible, however, that unless the sample is truly representative of the population, the results still may not be applicable to the country. Therefore, more large-scale studies using a representative sample of the population in more countries should investigate these associations.

Keeping in mind the limitations that were mentioned above, this study also found a consistent, strong relationship between gender and CRF, and males appeared to have greater CRF than did females. This finding appears to be aligned with the conceptual model, which suggests that gender is associated with the outcome of a health outcome (in this case, CRF). Some differences exist in the magnitude of this relationship, but this pattern was consistently found across sample sizes, study design, age, and country of origin; the one exception was a non-significant effect for studies from Asian countries. Results also indicated a significant effect of SES on CRF; those from a low SES were associated with lower CRF than were those from higher SES. Due to the limited number of effect sizes, moderation analyses were limited; however, this relationship does appear to remain constant, regardless of sample size and country of study. Based on the results of this study, it is important to be cautious in interpreting the results. The next section presents my recommendations for further research.

Recommendations

This meta-analysis was used to find that gender and SEP both had large effects on CRF; however, it is impossible to fully know the extent of their effect, without further studies that investigate the factors. Age was found to be a moderating factor between gender and CRF, but more research should be done to parcel out the differences between biological age (maturation) and chronological age (age in years) and their effects on CRF. Second, many studies examined in this meta-analysis used field tests that assessed VO_2 in relationship to body mass (ml/kg/min). Studies that were mentioned in earlier sections found that using other scaling (i.e., fat-free mass and allometric scaling) methods may reduce the differences between genders. As such, further studies should be conducted that examine whether these methods reduce the between-gender differences that exist with regard to CRF in different settings and contexts.

In this meta-analysis, SEP was also found to have a large effect on CRF. The low SEP group tended to have lower CRF compared to the high SEP group. This finding may impact adolescents who are from impoverished environments. Due to the limited studies retrieved for this meta-analysis, more studies should further investigate the association of

SEP on CRF in adolescents. The implications of this study and additional studies are described below.

Implications

The positive social change implications of this meta-analysis may provide evidence-based knowledge to physical educators and health educators who are considering changes in school health promotion policies concerning implementation of health promotion interventions geared toward different gender and socioeconomic groups. Current recommendations for physical activity and fitness testing for adolescents should continue until more research suggests that changes be made. Long-term results should include increased physical activity, decreased clustered cardiovascular risk factors, and lowered all-cause and cardiovascular disease mortality as adolescents track into adulthood.

Conclusion

Based on the evidence of this meta-analysis, there appears to be a strong association between gender and CRF and between SEP and CRF. However, more meta-analyses should be performed in order to investigate the potential moderators and the interaction of moderators that may impact the relationships between adolescents’ gender, SEP, and CRF.

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