Relationships among actual motor competence, perceived motor competence and health-related fitness in a college-aged population

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Relationships among Actual Motor Competence, Perceived Motor Competence and Health-Related Fitness in a College-Aged Population

by

Samantha Moss

Submitted in Partial Fulfillment of the Requirements for the Master of Science in Exercise Science Degree

Kinesiology Department

STATE UNIVERSITY OF NEW YORK AT COLLEGE AT CORTLAND

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Approved:

5-1-2018
Date
Larissa True, Ph.D.
Thesis Advisor

5-1-2018
Date
Erik Lind, Ph.D.
Thesis Committee Member

5/1/2018
Date
Peter McGinnis, Ph.D.
Thesis Committee Member

5-10-18
Date
Eileen Gravani, Ph.D.
Associate Dean, School of Professional Studies
ABSTRACT

Purpose: The purpose of this study was to assess relationships among actual motor competence, perceived motor competence, and health-related fitness in a college-aged population. Methods: A total of 76 participants from SUNY Cortland enrolled in an undergraduate Kinesiology course completed an informed consent form. Total data were obtained on 71 participants (male = 53; female = 18). Perceived motor competence (PMC) was assessed via the Physical Self Perception Profile questionnaire, which participants completed one week prior to remaining assessments. Motor competence (MC) was assessed by maximum throw and kick speed as well as maximum distance jumped. Health-related fitness (HRF) was assessed by a two-minute push-up test, two-minute sit-up test, and 20-meter Beep Test. Analysis: Pearson’s bivariate correlations were calculated to assess the relationships among PSPP total score, MC scores, and HRF scores for the total sample and separately by males and females. An overall MC index was calculated by averaging the maximum scores on throwing, kicking and jumping for each participant. An overall HRF index was calculated by averaging the maximum scores of push-ups, sit-ups and 20-meter Beep Test for each participant. Conclusion: MC, HRF, and PMC were differentially related for males and females. Overall, there were significant correlations between PSPP total score, MC index, and HRF index in a college-aged population. These findings may suggest that relationships among MC, HRF, and PMC strengthen over developmental time in young adults.
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CHAPTER 1

SUMMARY

Introduction

Many different factors attribute to the capability of an individual to perform skilled movement. Motor competence (MC) is defined as the ability to perform gross motor skills through fine and gross coordination (Lopes, Barnett, & Rodrigues, 2016). Examples of gross motor skills include but are not limited to throwing, catching, kicking, running, and jumping. Measures of MC have been studied fairly extensively in child populations in concert with perceived motor competence and health-related fitness (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008; De Meester et al., 2016: Luz, Rodrigues, De Meester, & Cordovil, 2017). Perceived motor competence (PMC) is defined as the way an individual perceives his or her own ability for performing motor skills and other physically-demanding tasks (Lopes et al., 2016). Health-related fitness (HRF) is the capacity of an individual to perform physical work, particularly in the domains of cardiorespiratory fitness, muscular fitness, muscular endurance, body composition, and flexibility (Casperson, Powell, & Christenson, 1985). By collectively assessing MC, PMC, and HRF, conclusions can be made about how these variables interact with one another. Even though there is a fair amount of literature regarding interrelationships of MC, PMC, and HRF in child populations, there is a great lack of literature in the adult population. It is hypothesized that the relationship among MC, PMC, and HRF will strengthen over developmental time (Stodden et al., 2008), but research does not currently exist confirming those interactions in a young adult population.
Statement of the Problem

The variables of PMC, MC, and HRF demonstrate a dynamic and reciprocal relationship in child and youth populations, but very little is known about the PMC/MC/HRF relationships in young adulthood. The importance of knowing this information will provide insight and clarity of what is actually happening throughout the human lifespan according to physical and motor capabilities. The current literature also lacks information regarding how these variables differ among men and women in the young adult population.

Purpose

The purpose of this study was to assess relationships among measures of PMC, MC, and HRF in a college-aged population.

Hypotheses

1. There will be a significant, positive correlation between PMC and various components of MC.

2. There will be a significant, positive correlation between various components of MC and various components of HRF.

3. There will be a significant, positive correlation between PMC and various components of HRF.

Delimitations

1. Only undergraduate students were used for this study.

2. Undergraduate students were only enrolled in SUNY Cortland.

3. For MC testing, tennis ball throwing speed, kickball kicking speed and jumping distance were measured.
4. For HRF testing, the push-up test, sit-up test, and the 20-meter Beep Test were measured.

**Limitations**

1. The radar gun (used to determine throwing and kicking speed) could have provided slightly different readings for all participants and may not have been 100% accurate throughout the study.
2. Human error is a factor when calibrating the radar gun and also when calculating average speed across trials.

**Assumptions**

1. Participants were truthful on their PMC questionnaire.
2. Participants were truthful regarding the exclusion criteria.
3. The radar gun was accurate among all participants.
4. Participants provided full effort in all tasks.

**Definition of Terms**

*Health-Related Fitness*  
Ability of the human body to successfully expend energy in leisure activities, become resistant to diseases and bacteria and to ultimately achieve being healthy (Caspersson et al., 1985).

*Motor Competence*  
Accomplishing different motor acts using fine and gross coordination (Lopes et al., 2016).

*Perceived Motor Competence*  
One’s subjective self-perception of their ability to execute various fine and gross motor skills (Lopes et al., 2016).
Significance of the Study

Throughout the last few decades, literature has shown that PMC, MC and HRF all play a role in overall development in youth populations. This study gathered information on these variables in a young adult (e.g., college-aged) population. These findings add to the scarce literature and provide further insight to the process of how PMC, MC and HRF influence an individual as a young adult.
CHAPTER 2
REVIEW OF LITERATURE

Many health professionals have emphasized that physical activity (PA) should be compulsory in youth as PA ultimately reduces the risk of various cardiovascular events (Reiner, Niermann, Jekauc, & Woll, 2013). Physical activity is defined as the movement produced by way of skeletal muscle to increase energy expenditure (Caspersen et al., 1985). Over the course of the last few decades, there has been a multitude of research emphasizing the importance of PA in youth populations and how good health habits transpire into adulthood (Freedman, Dietz, Srinivasan, & Berenson, 1999; McKenzie, Sallis, Broyles, Zive, & Nadar, 2002; Okley, Booth, & Patterson, 2001; Sallis, Prochaska, & Taylor, 2000). The Center for Disease Control and Prevention suggests that adults (18-64 years old) acquire 150 minutes of moderate-intensity aerobic activity per week and 2 or more days per week of muscle-strengthening activities. However, it seems hard to achieve these standards given the nation’s soaring obesity epidemic that consumes 1/3 of U.S. adults according to the Center for Disease Control and Prevention.

Health-related fitness (HRF) is the ability of the human body to successfully expend energy in leisure activities, become resistant to diseases and bacteria and to ultimately achieve being healthy (Hands, Larkin, Parker, Straker, & Perry, 2008; Stodden, True, Langendorfer, & Gao, 2013). Measures of HRF include muscular strength, muscular endurance and cardiorespiratory endurance (Stodden et al., 2013). This HRF is crucial to the development of children’s and adolescent’s overall well-being (Haga, Gísladóttir, & Sigmundsson, 2015). Greater HRF in youth will provide a better baseline of health as people grow into adulthood.
Motor competence is defined as the ability of an individual to accomplish different motor acts of fine and gross coordination (Lopes et al., 2016). MC is categorized as either locomotor (involving movement) or object control (object/ball manipulation), and there are many levels through which a person must progress to be considered a motor competent individual (Barnett et al., 2008). MC is related to the development of human movement and function (Luz et al., 2017). Perceived motor competence (PMC) is emerging as a predictor of MC and also a mediator between MC and PA in children and provides insight based on an individual’s perception of their skills (Khodaverdi, Bahram, Khalaji & Kazemnejad, 2013; Wang, Liu & Bian, 2013). Currently, there is scarcity of research on the young adult population in regard to their development of PMC and the impact it has on other variables.

Developing an adequate health status includes proficiency in HRF, MC, as well as maintenance of sufficient PA levels (Stodden et al., 2013). Less is known about the role that PMC plays in overall health. While there is a wealth of literature concerning relationships among HRF, MC, PA, and PMC, an overwhelming majority of the studies investigating these relationships have been conducted with youth populations. This review of literature will be presented using the following categories: Motor Competence and Physical Activity, Motor Competence and Health-Related Fitness, and Motor Competence and Perceived Motor Competence to deliver appropriate research and information regarding the relationships among these factors.

**Motor Competence and Physical Activity**

Recently, studies have emerged concerning the relationship of MC and PA; however, most of these studies are limited to samples in the toddler-childhood age range.
Research indicates that throughout the lifespan, low levels of MC are associated with poor PA (Lima et al., 2017; Lopes et al., 2016). Children typically have high MC because of organized activity through sports teams and clubs in which they participate. Research by Stodden et al. (2008) produced a theoretical framework describing the physical activity change from early childhood to adolescence. It was established that MC was enhanced due to structured and organized activities and sports at a young age. As children enter the adolescent years, those who participated in a range of sport-related activities perceive themselves to be motor competent, and thus they explore a variety of previously unexplored activities, and ultimately engage in more PA. Stodden et al. (2008) refers to this phenomenon as the “positive spiral of engagement.” This framework was confirmed through a longitudinal study conducted by Lima et al. (2017), in which 441 participants’ PA and MC were assessed across a span of 7 years beginning at age 6 and ending at age 13. The authors concluded that PA and MC displayed a reciprocal, longitudinal relationship beginning in middle childhood and continuing until adolescence.

A technique that has been used to assess MC and PA is the consideration of participants’ rank in either variable. A study conducted by Vedul-Klelsås, Stensdotter, Haga and Sigmundsson (2015) used the Movement Assessment Battery for Children (MABC) to assess MC. The age band for children 11-12 years was used and included eight subtests divided into three categories: 1) manual dexterity, 2) ball skills, and 3) static and dynamic balance. From this assessment, 26 were categorized in low MC and 41 in high MC. The measure of PA was demonstrated using a questionnaire. Results indicated that the low MC group reported less time spent in PA than the high MC group. These findings supported the theoretical model of Stodden et al. (2008).
Some researchers dispute the MC/PA relationship. Hands et al. (2008) assessed 1,585 adolescent participants in PA, MC and HRF. The participants PA was observed through a pedometer worn on the right hip for 7 days while HRF was measured through a series of different tests (chest pass, curl-ups, sit and reach, shoulder strength and body composition). Participants’ MC was assessed using the McCarron Assessment of Neuromuscular Development (MAND) that involves five fine motor tasks and five gross motor tasks. Results indicated that MC was significantly correlated with all HRF assessments but was not associated with PA. The authors rationalized these findings by stating that a limitation to their study included using a pedometer to analyze PA. A pedometer does not measure the intensity, type or frequency of PA and pedometers record locomotor movement. Their team hypothesizes that examining the HRF/MC relationship could be more revealing than the MC/PA relationship.

The correlation between MC and PA seems to be prevalent through these different findings. Though the literature indicates a relationship between the two in youth and adolescents, there is little knowledge on the impact this relationship has on the adult population.

**Motor Competence and Health-Related Fitness**

Currently, there is no universal definition of HRF; however, it can be interpreted as the capacity to perform physical functions or activities (Bouchard, 1993). There are many different tests that are used to evaluate HRF. Luz and colleagues (2017) recruited 546 children ($M_{age} = 10$ years old) using the PACER and handgrip test to assess HRF. The variable MC was assessed using three different tests: 1) stability (shifting platforms and lateral jumps), 2) locomotor (shuttle run and standing long jump) and 3) manipulative
(throwing velocity and kicking velocity). Results indicated a gender difference in that locomotor scores were more indicative of HRF in females and males while manipulative scores were more indicative of HRF in only males. Further, the authors found that regardless of age or sex, MC and HRF were moderately, positively associated with each other. Their findings were consistent with previous research (Castelli, & Valley, 2007; Haga, 2009; Vedul-kjelsås, Stensdotter, Haga, & Sigmundsson, 2012;). Barnett and colleagues (2008) used different measures, such as not including gender differences, to find results showing a positive relation between object control and HRF. These researchers used 244 adolescents to test MC by way of catch, kick, overhand throw, side gallop, vertical jump, hop and sprint run time. They assessed HRF by way of cardiorespiratory endurance. The 20-meter Beep Test was applied where the participants started at 20-meter running distance with a starting speed of 8.5 km/hr \(^{-1}\) and every two minutes the speed increased by .5 km/hr \(^{-1}\). These authors were the first to examine the relationship between childhood MC and adolescent HRF, concluding that the more proficient the child was in the MC testing, the more cardiovascular endurance they had in adolescent years. Iri, Aktug and Ibis (2017) recruited 1,718 adolescents in grades 5-7 to complete a Physical Activity Questionnaire for Adolescents (PAQ-A) and partake in a series of different MC tests. These tests included sit-ups, hand grip strength, standing long jump, flamingo balance test, the sit and reach flexibility tests and a 20-meter speed run to evaluate speed performance. They found that there were no significant differences found between PA and speed, standing long jump, flamingo balance and sit and reach tests.

While little is known about the relationship between MC and HRF throughout the lifespan and especially in older adulthood, one study exploring the MC/HRF relationship
in college-aged participants yielded strong results. Stodden, Langendorfer, and Roberton (2009) recruited 198 participants ($M_{age} = 20$ years old) to complete MC assessments consisting of throwing velocity, kicking velocity, and jumping distance. The HRF measures included a 12-minute walk/run, body fat percentage, curl-ups, grip strength, flexibility, and maximum leg press strength. The researchers found that with the exception of flexibility, all of the fitness measures were highly correlated to MC. In a follow-up study, Stodden and colleagues (2013) tested another group of college students ($n = 187$) using a similar approach. MC was assessed using throwing and kicking speed and jump distance, and HRF was assessed using the 12-minute walk/run, curl-ups, push-ups, grip strength and a three-repetition maximum unilateral leg press to assess strength. Rather than treating the MC and HRF variables as continuous measures, indices of each were created and participants were classified as having “good,” “fair,” or “poor” HRF as defined by Cooper Institute normative data (Cooper Institute, 2007), and were divided into “high,” “moderate,” or “low” according to their transformed z-score index for MC. Of the 65 participants classified as low-skilled, 61.5% of those participants were also classified as “poor” on the HRF tests. Of the 40 participants who were classified as highly skilled on MC testing, 52.5% of those participants were ranked as having “good” fitness. These two studies highlight the role that MC plays during childhood towards developing proper HRF habits into adulthood. It can also be inferred that children with low MC will be at a greater risk later in life for poor muscular endurance, poor muscular strength, and poor cardiorespiratory endurance (Stodden et al., 2013).

Adding to the limited adolescent literature regarding HRF and MC, Haga and associates (2015) recruited 194 participants to assess the MC/HRF relationship in three age
groups (4-6, 11-12 and 15-16). Measures of MC was determined using the Movement Assessment Battery for Children (MABC) and the Movement Assessment Battery for Children-2 (MABC-2), which examines manual dexterity, speed and sureness, hand-eye coordination, aiming, catching, dynamic balance, and static balance. Within the MABC, each age group has different tasks to complete; the tasks increase in difficulty as the age of the participant increases. To assess HRF, participants completed the standing broad jump, 20-meter run, and the 6-minute walk test. Results indicated moderately strong, significant correlations between MC and HRF in the 4-6 and 11-12 age groups. Significantly lower correlations between MC and HRF were found in the adolescent age group (15-16 years old). The authors attributed this finding because MC has a greater effect on executions of fitness tasks at a younger age. For example, in the 4-6-year-old age group, running is not as well-developed as the older age groups. Due to their immature running pattern, this could be a more daunting task for younger participants than older participants. This may be an easier motor task for the older age groups then compared to the younger ones. These findings contradicted the Stodden et al. (2009) study that showed a strong, positive relationship between MC and HRF in college students, and also contradicts Stodden and colleagues (2008) hypothesis that the relationship between MC and HRF would strengthen over developmental time.

Previous to the 2015 study, Haga (2009) recruited a sample of 18 children and divided the sample into low MC (LMC) or high MC (HMC) based on their MABC percentile scores. The Test of Physical Fitness (TPF) was used to assess the children’s HRF. Several tasks were used including standing broad jump, jumping a distance of 7-meters on both feet as quickly as possible, jumping a distance of 7-meters on one foot as
quickly as possible, throwing a tennis ball with one hand as far as possible, pushing a
medicine ball with both hands simultaneously as far as possible, climbing wall bars,
crossing over two columns to the right, and going down the fourth column as quickly as
possible, shuttle sprint running 20-meters as quickly as possible, and the reduced Cooper
test. Findings indicated that there were significant differences between the LMC group and
the HMC groups across all measures of HRF, with the HMC group consistently outscoring
the LMC group. This study is in accordance with other findings validating the positive
relationship MC and HRF exhibit (Vedul-Klelsás et al., 2015).

Throughout the different pieces of literature, the results of the relationship between
HRF and MC show that they are related even by use of different assessments and tests.
Literature seems to show the greater MC the greater HRF one will have. It can be inferred
that this correlation will carry through to adulthood. There is, however, limited research to
substantiate this theory.

**Motor Competence and Perceived Motor Competence**

While MC is defined as an individual’s actual ability to execute gross and fine
motor skills (Lopes et al., 2016), PMC is defined as an individual’s subjective self-
perception of their ability to execute various fine and gross motor skills (Lopes et al.,
2016). However, even though PMC is clearly defined in the literature, Rodgers, Markland,
Selzler, Murray and Wilson (2013) published a study to determine the difference between
PMC and self-efficacy. Self-efficacy is defined as a situation-specific self-confidence that
one harbors (Rodgers et al., 2013). The sample was comprised of 357 adults identified as
healthy sedentary adults. Participants completed the Psychological Need Satisfaction in
Exercise (PNSE) 18-item self-report questionnaire to assess the degree of fulfillment
associated with the psychological needs for competence, autonomy, and relatedness. To analyze self-efficacy, participants completed the Multidimensional Self-Efficacy for Exercise Scale, which is a nine-item self-report questionnaire that represents three behavioral domains of self-efficacy (task, scheduling, and coping). Answers ranged from “I have no confidence” to “I have complete confidence.” The researchers then replicated this study with a group of 244 undergraduate students who were deemed “healthy and active.” A comparison of the two samples indicated that there are empirical distinctions at the measurement level between PMC and self-efficacy, thus defining PMC as its own source of measurement. While the two constructs are likely to be related, they are not purported to measure the same phenomenon (Rodgers et al., 2013). Self-efficacy and PMC require different measurements and are distinguished between each other. It is important to understand that PMC is not the same as self-efficacy and cannot be measured the same or be used interchangeably (Rodgers et al., 2013).

As the theoretical framework of Stodden and colleagues (2008) describes, children with better MC are not only hypothesized to a higher PA level, but also a higher PMC. Lopes and colleagues (2016) used this framework as a pillar to analyze the association between MC and PMC among preschool children, and they found a significant but low correlation between PMC and MC. They attributed the low correlation to the age of the participants ($M_{age} = 4$ years old) and hypothesized that the preschoolers’ cognitive perceptions may have not developed yet, thus not allowing them to accurately depict themselves completing a motor task.

De Meester and colleagues (2016) investigated the MC/PMC relationship in a sample of adolescents. PMC was assessed using the Children and Youth Physical Self-
Perception Profile, and MC was assessed using the Köperkoodinationstest für Kinder (KTK). The KTK includes four subtests: 1) walking backwards along balance beams of decreasing width, 2) moving sideways by stepping on and moving two wooden boards for 20 seconds, 3) two-legged jumping from side to side for 15 seconds, and 4) one-legged hopping over foam obstacles of increasing height. Their results indicated that adolescents’ PMC was significantly, positively related to MC. It was also demonstrated that participants with a low MC and high PMC were the most prevalent combination in the findings. It can be inferred that adolescents with a higher PMC actually performed the motor competency tests better. It was also seen that adolescents who overreached their abilities on the PMC questionnaire did not perform as well.

Wang et al. (2013) examined the PMC/MC relationship in a sample of college students, specifically basketball players (n = 114) from two academic majors (physical education and liberal arts). The age of participants ranged from 18-48 years old. The Perceived Competence Scale was used to assess PMC and actual MC was tested with the Control Basketball Dribble Test. The authors developed a four-item questionnaire using statements such as, “I feel confident in my ability to play basketball”, and “I feel capable playing basketball”. Participants had to dribble a basketball as fast as possible maneuvering around cones in a basketball court and time was recorded. They found that PMC in basketball dribbling was significantly and inversely correlated to basketball dribbling time. Furthermore, PMC was significantly associated with basketball dribbling time for college students. These findings could be replicated in a more accurate undergraduate college population (18-24 years old), with respect to basketball dribbling.
Within the literature, there are mixed findings. The three aforementioned studies seem to agree that the PMC/MC relationship strengthens with age (De Meester et al., 2016; Lopes et al., 2016; Wang et al., 2013). However, other studies have reported significant relationships between PMC and object control skills but not with locomotor skills (Barnett et al., 2008). Similarly, Castelli and colleagues (2007) found a significant correlation between PMC and throwing/paddle activities, but no correlation with basketball skills, which disputes the findings of Wang et al., (2013).

There is sufficient evidence in the literature to indicate the MC and PMC are related, but less is understood about how this relationship changes over developmental time. Further, MC and PMC are significant predictors of PA (Barnett et al., 2008; Khodaverdi et al., 2013; Ulrich, 1985). It can be inferred that PMC plays a significant role in the development of MC and PA behaviors and may also influence HRF. More research is necessary to confirm the dynamic role of PMC and MC in older populations.

**Summary**

To summarize, MC is positively correlated to PA (Lima et al., 2017; Lopes et al., 2016; Vedul-Klelsås et al., 2015). Many studies have conflicting reports as to which subset of MC (object control versus locomotor) is a better predictor or correlate of PA (Barnett et al., 2008; Fisher et al., 2005; Williams et al., 2008). Overall, the understanding of the PA/MC relationship is still somewhat inconclusive regarding non-youth populations. As for MC and HRF, Haga and associates (2015) found stronger correlations in the 4-6 and 11-12-year-old age groups while there were no correlations between MC and HRF in the 15-16-year-old age group. Stodden and colleagues (2009) also found moderate-to-high correlations between HRF and MC in young adults. Their work has provided the strongest
evidence to date comparing the relationship between MC and HRF. Luz et al. (2017) found that locomotor skills were a stronger predictor of HRF in females and object control skills were a strong predictor of HRF in males.

In terms of the relationship between PMC and MC, research indicates that there is little to no association between PMC and MC in preschool children (Rodgers et al., 2013), but a strong correlation in PMC and MC in college-aged basketball players (Wang et al., 2013). Overall, the literature regarding the various relationships between MC, PA, HRF, and PMC have varied conclusions, which may be the result of the many age groups that have been studied. There is a large lack of research using these measures in a college-aged population. Current research has typically used toddler-teenage samples, so the knowledge of these variables on the college-aged population is restricted.

The current study aims to understand the relationship between the MC, PMC and HRF in a college-aged sample. This study will be unique due to the complexity and types of measures being used. Measures of MC, PMC and HRF testing will all be used in one complete study with a very exclusive population. Collectively, these variables have not been examined in a college-aged sample; therefore, this study will add to the current research due to the age of sample and methods of measuring the dependent variables.
CHAPTER 3
RESEARCH BRIEF

Methods

The aim of the proposed study was to assess relationships among MC, PMC, and HRF in a sample of college aged students. The following sections (participants, measures, procedures and data analysis) describe how the study was conducted.

Participants. There were 76 participants from State University of New York (SUNY) at Cortland that were recruited from four Motor Behavior laboratory sections within the Kinesiology department. Students had the option of either completing the previously scheduled lab for that day or participating in the study. On the day of testing, all lab classes met at the Multi-Activity Court within SUNY Cortland’s Student Life Center where 71 of the original 76 recruited participants were assessed in MC and HRF. Two males were absent on the day of testing and three females opted out of participating in the MC and HRF testing. Within the publicly viewed facility, there was a lab station set up for the students who chose not to participate in the study. All other participants were directed to the open area of the court to begin testing. Students that chose to participate earned the same number of points that could have been earned by doing the lab, assuming completion of all measures. Participants with previous major orthopedic injuries requiring surgery in the last six months or cardiac issues were excluded from this study. Recruitment did not begin until approval from SUNY Cortland’s Institutional Review was obtained. Participants completed an informed consent document prior to the start of testing.
Measures.

**Demographics and anthropometrics.** In total, 76 participants self-reported their age and sex on a brief survey attached to the informed consent document. Participants’ standing height and weight were directly measured using a portable stadiometer (Chadar, HM 200P Portstad, Tiwan) and a portable scale (Omron, HN-286, Singapore). Their height was measured to the nearest 0.1 cm while their weight was measured to the nearest 0.1 kg.

**Perceived motor competence.** To assess PMC, the revised version of the Physical Self-Perception Profile (Kalmet & Fouladi, 2008) was distributed to the 76 participants the week before the MC and HRF testing began. The questionnaire was designed to assess participants’ thoughts on how well they perceive their performance of certain motor skill tasks. There were five subscale items including sports competence, physical condition, body attractiveness, physical strength and physical self-worth. Total scores ranged from 6-24 with a higher score indicating a higher self-perception.

**Motor competence.** Gross MC was assessed in a single testing session through a series of three tests. Students were instructed to throw a tennis ball “as hard as possible” to a wall with no target from a distance of approximately 9-meters. The researcher operated a Bushnell Velocity Speed radar gun (Bushnell, 101911, China) to measure speed by standing approximately 1-meter behind the participant and at an approximated 45-degree angle. Participants completed five trials of the throw and the maximum speed among the five trials was retained for analysis. Students were then instructed to kick a soccer ball “as hard as possible” and speed was again measured using the Bushnell Velocity Speed radar gun with the researcher standing approximately 45-degrees behind the participant.
Participants completed five trials of the kick and the maximum speed among the five trials was retained for analysis. For the final measure of MC, participants performed five trials of the standing long jump. Participants stood behind a line next to a tape measure and were instructed to “jump as far as possible,” landing on two feet. A member of the research team marked where the participant’s heel that was closest to the starting line landed and recorded the distance jumped. The maximum jump distance across the five trials was retained for analysis and divided by the height of the participant to create a standardized variable (e.g., jump distance/height).

**Health-Related Fitness.** Participants completed three tasks to assess HRF: number of push-ups in two minutes, number of sit-ups in two minutes and the 20-meter Beep Test. A timed push-up test was used to assess upper-body strength and endurance. Participants were given a demonstration by a member of the research team on how to properly execute a non-modified push-up. Following the demonstration, participants were asked to find a partner. One partner counted silently while the other partner completed the test. The active participant completed as many push-ups as possible in a span of two minutes while the other participant counted the number of successfully completed push-ups and recorded the number on a data collection sheet. The test was self-paced (e.g., participants could stop and rest and then resume again during the two minutes); however, if a push-up was executed with improper form, it was not counted. The number of correctly executed push-ups was recorded. After the active participant completed the test, the partners switched roles and repeated the test. Next, abdominal strength and endurance were assessed using a sit-up test. Participants were given a demonstration of proper sit-up form by a member of the research team. Participants were given two minutes to complete as many sit-ups as possible. Still in
pairs, one participant performed the test while the other participant was actively assessing sit-up form of their partner and counted the amount completed in two minutes. A visual check of sit-up form was included validating that the shoulders were lifted off the ground with their hands placed across their chest. The test was self-paced (e.g., participants could stop and rest and then resume again during the two minutes); however, if a sit-up was executed improperly, it was not counted toward the total. After the active participant completed the test, the partners switched roles and repeated the test. The final measure of HRF was the 20-meter Beep Test to examine cardiorespiratory endurance. Still in pairs, participants lined up on one end of the court with one partner actively participating and the other partner recording. A line 20-meters from the starting line was indicated to participants, who were instructed to run to the opposing line after hearing a “beep.” Once participants crossed the opposing line, they were instructed to wait for the next “beep” before running back to the original starting point. This process continued with increasing frequency of beeps. The initial minimum running velocity to match the timing of the beeps was 8.5 km/hr$^{-1}$ and increased by .5 km/hr$^{-1}$ each minute. When participants were further than 2-meters from the line when the beep sounded (or when participants self-selected to stop running), their test was completed, and the number of laps was recorded. After the active participant completed the test, the partnersswitched roles and the test was repeated.

**Procedures**

Participants completed the informed consent, PMC questionnaire, and had their height and weight taken by the researcher one week prior to the testing day. The MC tests and the HRF tests, in that order, were completed at the SUNY Cortland Student Life Center in the Multi-Activity Court which was an easily-accessible location for students.
Upon arrival, the MC testing took place. Throwing speed was measured first, followed by kicking speed. Participants measured jump distance while waiting to complete the throwing and kicking measures. After all the MC tests were completed for all participants, the HRF portion took place. The push-up test was conducted first, followed by the sit-up test. Both tests had alternating turns for their partners, which allowed for adequate rest time between the throwing and push-up assessments. Finally, the 20-meter Beep Test was conducted, and the number of laps successfully completed was recorded for analysis.

**Data Analysis**

All data were analyzed using IBM SPSS version 25. Means and standard deviations were calculated for age, height, weight and BMI among the total sample and separately for males and females. Means and standard deviations were also calculated for all variables of MC, HRF and PSPP total score for the total sample and separately by males and females. A series of correlation analyses were run to determine the relationship between the variables for the total group and separately by males and females. An MC index was created as an “overall MC” score for each participant by averaging maximum scores on throwing, kicking, and jumping. An HRF index was calculated as an “overall HRF” score for each participant by averaging the number of push-ups, sit-ups, and laps completed. Pearson’s bivariate correlations were calculated on individual scores (e.g., throwing, jumping, sit-ups, laps, PSPP, etc.) for the total sample and separately by males and females. Pearson’s bivariate correlations were also calculated for the index scores and PSPP for the total sample and separately by sex where significant correlations were represented.
Results

Consent forms were obtained from 76 participants; the PSPP survey was attached to the consent form, so all participants who completed the consent form completed the PSPP. Height and weight were obtained from 76 participants upon completion of the consent form. Of the 76 participants who granted consent, 71 completed the MC and HRF measures. Participants with missing data in the MC and HRF components were excluded from any data analyses that included those variables.

Physical Characteristics. The mean ± SD values of physical characteristics of the total sample and by males and females are presented in Table 1. The majority of the sample (72.3%) were male. Males were significantly taller, $t(74) = -9.093$, $p < .01$ and heavier, $t(74) = -4.169$, $p < .01$ compared to females. No significant differences were found between males and females in terms of age or BMI percentile.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means and Standard Deviations of Physical Characteristics of Females, Males, and Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n = 76)</td>
</tr>
<tr>
<td>Age</td>
<td>20.53 ± 1.71</td>
</tr>
<tr>
<td>Height (m)**</td>
<td>1.74 ± .08</td>
</tr>
<tr>
<td>Weight (kg)**</td>
<td>76.65 ± 12.98</td>
</tr>
<tr>
<td>BMI</td>
<td>25.34 ± 3.86</td>
</tr>
</tbody>
</table>

Notes:
** = statistically significant differences between males and females, $p < .01$
Table 2 shows the means ± SD of the MC variables (throw max, kick max, jump max, and the MC index), HRF (20-meter Beep Test, push-up test, sit-up test, and HRF index) and PSPP total score for the total sample and by males and females. Males significantly outperformed females on all MC measures, including the MC index, push-ups, 20-meter Beep Test, and the HRF index ($p < .01$ for all group differences). The only score for which there were no gender differences was sit-ups. Males also had significantly higher PSPP scores compared to females, $t(74) = -3.356, p < .01$.

Table 2

*Means and Standard Deviations of Motor Competence, Health Related Fitness, and Perceived Competence*

<table>
<thead>
<tr>
<th></th>
<th>Total ($n = 71$)</th>
<th>Male ($n = 53$)</th>
<th>Female ($n = 18$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throw max (mph)**</td>
<td>57.85 ± 12.80</td>
<td>62.58 ± 10.14</td>
<td>43.89 ± 9.15</td>
</tr>
<tr>
<td>Kick max (mph)**</td>
<td>44.08 ± 6.09</td>
<td>46.25 ± 4.926</td>
<td>37.72 ± 4.56</td>
</tr>
<tr>
<td>Jump max (m)**</td>
<td>1.18 ± .18</td>
<td>1.24 ± .17</td>
<td>1.01 ± .12</td>
</tr>
<tr>
<td>MC index**</td>
<td>34.37 ± 5.74</td>
<td>36.69 ± 4.28</td>
<td>27.54 ± 3.70</td>
</tr>
<tr>
<td>Beep test (laps)**</td>
<td>43.08 ± 18.02</td>
<td>47.51 ± 17.75</td>
<td>30.29 ± 11.86</td>
</tr>
<tr>
<td>Push-up test (#)**</td>
<td>54.91 ± 17.55</td>
<td>53.20 ± 18.54</td>
<td>32.65 ± 9.78</td>
</tr>
<tr>
<td>Sit-up test (#)</td>
<td>47.99 ± 18.96</td>
<td>54.86 ± 17.66</td>
<td>55.06 ± 17.77</td>
</tr>
<tr>
<td>HRF index**</td>
<td>48.51 ± 13.58</td>
<td>51.69 ± 13.26</td>
<td>39.33 ± 10.10</td>
</tr>
<tr>
<td>PSPP total**</td>
<td>89.39 ± 12.98</td>
<td>92.29 ± 11.11</td>
<td>81.81 ± 14.68</td>
</tr>
</tbody>
</table>

*Notes:*
MC = motor competence
HRF = health related fitness
PSPP = physical self-perception profile
** = statistically significant differences between males and females, $p < .01$
Motor Competence, Health Related Fitness, and Perceived Motor Competence. For the total sample of participants, Pearson’s bivariate correlations among the individual variables comprising the MC and HRF constructs (e.g., throw, kick, jump, 20-meter Beep Test, push-ups, and sit-ups) as well as the PSPP total score are presented in Table 3. The analyses showed significant correlations at the $p < .01$ level and the $p < .05$ level between all variables except sit-ups and throwing, sit-ups and kicking, sit-ups and jumping, and sit-ups and PSPP total score. The strongest relationship between variables for the total sample was between push-ups and jumping ($r = .692, p < .01$).

Table 3
Pearson’s Bivariate Correlations Between Individual Scores for Total Sample ($n = 71$)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Throw max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Kick max</td>
<td>.590**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Jump max</td>
<td>.587**</td>
<td>.591*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. Beep test</td>
<td>.304*</td>
<td>.312*</td>
<td>.523*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sit-up test</td>
<td>.016</td>
<td>.099</td>
<td>.235</td>
<td>.384**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Push-up test</td>
<td>.417**</td>
<td>.487*</td>
<td>.692**</td>
<td>.375**</td>
<td>.252*</td>
<td></td>
</tr>
<tr>
<td>7. PSPP total</td>
<td>.323**</td>
<td>.434**</td>
<td>.371**</td>
<td>.325**</td>
<td>.135</td>
<td>.403**</td>
</tr>
</tbody>
</table>

Notes:
* = statistically significant at the $p < .05$ level
** = statistically significant at the $p < .01$ level

For the females in the sample, Pearson’s bivariate correlations among the individual variables comprising the MC and HRF constructs (e.g., throw, kick, jump, 20-
meter Beep Test, push-ups, and sit-ups) as well as the PSPP total score are presented in Table 4. Results indicated a significant inverse correlation between sit-ups and throwing \((r = -0.553, p < .05)\), a significant positive correlation between sit-ups and push-ups \((r = 0.645, p < .05)\), and the strongest relationship between variables in the female sub-sample emerged between push-ups and jumping \((r = 0.536, p < .01)\). There were no other significant correlations between variables in the sub-sample of females.

Table 4

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.553**</td>
<td>-.190</td>
<td>.060</td>
</tr>
<tr>
<td></td>
<td>.225</td>
<td>.070</td>
<td>-.025</td>
<td>.087</td>
<td>-.145</td>
<td>.011</td>
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<td></td>
<td></td>
<td>.206</td>
<td>.065</td>
<td>.372</td>
<td>.536*</td>
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<td>.319</td>
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<td>.482</td>
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<td>.645**</td>
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<td></td>
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<td></td>
<td>.302</td>
</tr>
</tbody>
</table>

Notes:
* = statistically significant at the \(p < .05\) level
** = statistically significant at the \(p < .01\) level

For the males in the sample, Pearson’s bivariate correlations among the individual variables comprising the MC and HRF constructs (e.g., throw, kick, jump, 20-meter Beep Test, push-ups, and sit-ups) as well as the PSPP total score are presented in Table 5. The analysis indicated significant correlations between kicking and throwing \((r = 0.352, p < .01)\), jumping and throwing \((r = 0.467, p < .01)\), 20-meter Beep Test and jumping \((r = 0.405, p < .01)\),
$p < .01$), sit-ups and 20-meter Beep Test, ($r = .509, p < .01$), and PSPP and push-ups ($r = .410, p < .01$). Jumping and kicking were significantly related ($r = .591, p < .05$), as were jumping and PSPP ($r = .350, p < .05$). The strongest relationship for men in the sample was between push-ups and jumping ($r = .601, p < .01$).

Table 5

*Pearson’s Bivariate Correlations Between Individual Scores for Males (n = 71)*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Throw max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Kick max</td>
<td>.352**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Jump max</td>
<td>.467**</td>
<td>.433*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Beep test</td>
<td>.069</td>
<td>.070</td>
<td>.405**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sit-up test</td>
<td>.199</td>
<td>.144</td>
<td>.260</td>
<td>.509**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Push-up test</td>
<td>.230</td>
<td>.345*</td>
<td>.601**</td>
<td>.201</td>
<td>.236</td>
<td></td>
</tr>
<tr>
<td>7. PSPP total</td>
<td>.214</td>
<td>.242</td>
<td>.350*</td>
<td>.229</td>
<td>.162</td>
<td>.410**</td>
</tr>
</tbody>
</table>

*Notes:*

* = statistically significant at the $p < .05$ level

** = statistically significant at the $p < .01$ level

For the total sample, Pearson’s bivariate correlations were calculated among the three main constructs (e.g., MC index, HRF index, and PSPP total score). Results are presented in Table 6. All constructs within the total sample were significantly related at $p < .01$. The strongest relationship was between the PSPP total score and the MC index ($r = .397, p < .01$).
Table 6

*Pearson’s Bivariate Correlations Between MC Index, HRF Index and PSPP Total in Total Sample (n = 71)*

<table>
<thead>
<tr>
<th></th>
<th>MC Index</th>
<th>HRF Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRF index</td>
<td>.390**</td>
<td></td>
</tr>
<tr>
<td>PSPP total</td>
<td>.397**</td>
<td>.378**</td>
</tr>
</tbody>
</table>

Notes:
** = statistically significant at the p < .01 level

For the females in the sample, Pearson’s bivariate correlations were calculated among the three main constructs (e.g., MC index, HRF index, and PSPP total score). Results are presented in Table 7. No significant correlations among the three variables existed.

Table 7

*Pearson’s Bivariate Correlations Between MC Index, HRF Index, PSPP Total in Female Sample (n = 71)*

<table>
<thead>
<tr>
<th></th>
<th>MC Index</th>
<th>HRF Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRF index</td>
<td>-.311</td>
<td></td>
</tr>
<tr>
<td>PSPP total</td>
<td>.289</td>
<td>.868</td>
</tr>
</tbody>
</table>

For males in the sample, Pearson’s bivariate correlations were calculated among the three main constructs (e.g., MC index, HRF index, and PSPP total score). Results are
shown in Table 8 and indicated that the PSPP total score and HRF index were significantly related ($r = .355, p < .05$). No other significant relationships were found.

Table 8

<table>
<thead>
<tr>
<th></th>
<th>MC Index</th>
<th>HRF Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRF Index</td>
<td>.276</td>
<td></td>
</tr>
<tr>
<td>PSPP Total</td>
<td>.266</td>
<td>.355*</td>
</tr>
</tbody>
</table>

*Notes:*

* = statistically significant at the $p < .05$ level

**Discussion**

The purpose of this study was to investigate relationships among MC, HRF and PMC in a college-aged sample. A total of 76 participants (males, $n = 55$; females, $n = 21$) with an average age of 20 years completed the anthropometric measures and the PSPP while a total of 71 participants (males, $n = 53$; females, $n = 18$) completed the MC and HRF tests in the current study. In general, and for the total sample, significant correlations among MC, HRF, and PMC were evident within a college-aged population. However, differences in the correlations between males and females were found.

Age and body mass index (BMI) did not differ significantly by sex but men were significantly taller and weighed more than women (Table 1). The sample had an average BMI of $25.34 \pm 3.86$, which falls just within the overweight classification according to Centers for Disease Control and Prevention. Anecdotally speaking, the sample was physically fit and are likely more physically active than the general population. This could
be due to the sample being comprised exclusively of Physical Education and Coaching majors. The majority of the sample were observed as having an “athletic” body type that may not be fully represented by the BMI variable. BMI was calculated by dividing weight (kg) by height squared (m) and does not take into account body fat percentage or lean muscle mass. Having an overall athletic sample could potentially skew the BMI values that were attained.

Table 2 presents means and standard deviations of MC variables and MC index, HRF variables and HRF index, and PSPP scores for the total sample and separately for males and females. There were sex differences for all measured variables except for sit-ups. This is an interesting finding especially for a sample that is highly fit. According to the National Strength and Conditioning Association, females between the age of 18-25 years who can execute 68 sit-ups in two minutes are ranked in the 90th percentile. As for males of the same age bracket, performing 77 sit-ups in two minutes is characterized as the 90th percentile. Average sit-ups completed by the total sample was 47.99 sit-ups, which would rank males and females, collectively, in the 50th percentile. This could be attributed to the wide range of results for both males ($R = 15-94$ sit-ups) and females ($R = 30-94$ sit-ups). Having such a wide range speaks to how inconsistent abdominal strength/endurance is even with a highly fit population. This is, however, in accordance to Ryman et al. (2009) who also found no significant differences in number of sit-ups between males and females. Their study consisted of a total of male ($n = 25$) and female ($n = 38$) college students to assess sex differences and reliability of the push-up and sit-up tests.

With the exception of the sit-up variable, the findings were in agreement with Stodden et al. (2009), who found that males outperformed females on HRF tasks (curl-ups,
grip strength, 12-min run/walk) and MC tasks (throwing, kicking, and jump/height); the MC tasks in the Stodden study were measured in the same manner as the current study. We did not expect to see such vast differences between males and females in terms of jump distance because maximum jump distance was normalized to the individual’s height and males were significantly taller than females. The jump/height differences, however, do mirror the other sex-based differences in the MC and HRF variables (with the exception of sit-ups). Males in our sample significantly outperformed females on the kicking and throwing measures. Kicking and throwing are classified as object control skills and are skills that are typically used in sport-specific endeavors. According to Sgro, Quinto, Messana, Pignato, and Lipoma (2017) sex differences in performance of object control tasks are evident throughout developmental time. Their study included children ($M_{age} = 8.7$ years) from different grade levels in school. In terms of object control tasks similar to those assessed in the current study, there were no sex differences in children enrolled in Year-1, but within the Year-2, Year-3 and Year-5 cohorts, sex differences in object control skills became more evident with increasing age. Similarly, in an adolescent sample, Valtr, Psotta, and Abdollahipour (2016) found that males significantly outperformed females in aiming and catching tasks ($r = .20-.33, p < .001$), respectively. Typically, very young children will not exhibit sex differences within object control skills but throughout developmental time, sex differences in object control skills start to emerge. This paradox is also seen in a study by Stodden et al., (2009), who found significant differences in object control skill between males and females in a college-aged population. Throughout the literature, it is apparent that the differences in object control skills between men and women will increase throughout developmental time.
Many significant correlations among the individual MC scores, individual HRF scores, and PSPP score existed when the total sample was considered (Table 3). In general, the findings indicated that throwing, kicking, and jumping performance was significantly related to cardiovascular endurance, upper-body strength, and PMC. We contend that the relationship between the individual MC measures to two of the three HRF measures is an important one. It is possible that individuals who are highly skilled in throwing, jumping, and kicking were exposed to these activities as children, and this exposure promotes their subsequent (e.g., adulthood) levels of HRF (Stodden et al. 2008). One longitudinal study examined children’s (n = 1045) motor skill proficiency in comparison with their adolescent (grades 10 and 11; n = 244) object control, locomotor, and cardiorespiratory fitness (Barnett et al., 2008). Their findings suggested that childhood object control was the strongest predictor of cardiorespiratory fitness in adolescence. Although our examination was not longitudinal, we found that cardiorespiratory fitness (e.g., 20-meter Beep Test) was significantly related to throwing and kicking, both of which are object control skills, and jumping, which is a locomotor skill. Interestingly, the strongest correlation between any of the HRF measures and MC measures was between the 20-meter Beep Test and jumping. Though our findings in this lens differ from Barnett et al. (2008), it is intuitive that jumping and our measure of cardiorespiratory fitness (e.g., running) would be related because they are both locomotor skills.

The sit-up variable in our total sample was not significantly related to throwing, kicking, jumping, or PSPP. This contradicts Stodden et al. (2009), who found weak but significant correlations between curl-up and throw, kick, and jump (r = .48, r = .49, r = .59, respectively). Our lack of findings here could be attributed to the order of testing. By
the time participants completed the sit-ups, they had warmed up, completed five trials of throwing, five trials of kicking, and 2-minutes of push-ups. It is possible that for some participants, their core was fatigued from the other measures and it hindered their sit-up performance even though the sample was deemed to be athletic. Activities or exercises performed the previous day were not recorded and could have left participants fatigued.

For our total sample, PMC was significantly correlated to both object control skills (throw and kick), which agrees with a previous study by Wang et al. (2013) that analyzed the relationship between PMC and the Control Basketball Dribble Test. The test measured actual MC by dribbling a basketball as fast as possible around a series of cones. Their measure of PMC was a questionnaire specifically related to basketball with items such as, “I feel confident in my ability to play basketball.” The sample in the Wang et al. (2013) study was similar to ours in that 114 college students who were primarily Physical Education or Kinesiology majors participated. Results of this study showed that PMC between males and females did not differ, and that basketball-specific PMC was statistically significantly and inversely related to basketball dribbling time ($r = -.55, p < .01$). Therefore, higher scores on the PMC measure were associated with a faster/shorter dribble time.

The current study indicates similar results for PMC and individual measures of MC, with the strongest correlations being between kicking and PMC. Our findings also show a statistically significant correlation between PMC and the 20-meter Beep Test ($r = .325, p < .01$), and PMC and push-ups ($r = .403, p < .01$). Thus, individuals who are more skilled perceive themselves higher than those who are less skilled. A study done by Xiangli, Thomas, and Yu-Lin (2017) found similar correlations in their child population.
The researchers used the same mode of measuring cardiorespiratory fitness and measured MC by using PE Metrics which included gymnastics and soccer skills. Measures of PMC were assessed by a five-question Likert-scale. They found significant correlations between PMC and cardiorespiratory fitness ($r = .42$, $p < .01$), respectively. The significant correlations between PMC and various MC measures supports the framework created by Stodden et al. (2008) hypothesizing that the PMC/MC relationships will strengthen over developmental time.

Relationships among throw max, kick max, jump max, 20-meter Beep Test, push-ups, sit-ups and PSPP total were assessed exclusively in females (see Table 4). For females in our sample, throwing and sit-ups were inversely correlated, indicating that females who threw harder performed less sit-ups. These findings suggest that females who are more fit may devote more time to activities that are physically-demanding and fitness-based rather than on skill-based activities. This could also suggest that females who are more skilled at an object control task like throwing tend to focus their active endeavors on more sport-specific ballistic skills rather than physical fitness, which would increase abdominal strength/endurance. Our findings differ from those of Stodden et al. (2013), who found a low, positive correlation between curl-up and throwing speed ($r = .21$, $p < .05$) in an all-female sample. The discrepancy between findings could be attributed to the small female sample size of the current study ($n = 18$) compared to Stodden et al. (2013) ($n = 109$); however, the ages between studies were comparable ($M_{\text{age}} = 20.4 \pm 1.4$ years and $M_{\text{age}} = 20.53 \pm 1.71$), respectively. We contend that a larger sample size may have elicited stronger correlations, and possibly a different result regarding sit-ups and throwing in females.
Males overall had more significant correlations than females did among individual MC variables, individual HRF variables, and PSPP (Table 5). Jump distance was the most-correlated variable, with significant correlations to all variables except sit-ups. Similarly, Stodden et al. (2009) found that jumping explained most of the variance in HRF relative to throwing and kicking. They attributed this finding to individuals that are skilled in jumping might also partake in other sports/activities that stimulate leg strength and other aspects of physical fitness. There were no significant correlations between 20-meter Beep Test and throw or kick in males, indicating that—at least for males in our sample—cardiorespiratory fitness was not associated with object control skill. These findings dispute a study done by Luz and colleagues (2017). Their study measured cardiorespiratory fitness using the 20-meter Beep Test compared to stability, locomotor, and manipulative skills in 546 children ($M_{age} = 10.8$ years). They found that manipulative tasks were the best predictor of HRF in boys ranging from 7-10 years old and attributed their findings to gender differences in sports performance. The only correlations that existed for PMC were between push-ups and jump max in males. The push-up test was a measure of upper body strength/endurance. Especially in males, hypertrophy and muscle size that is developed through fitness endeavors, is something that is outwardly obvious. Males could have perceived themselves as stronger, and in turn can do more push-ups, because of their physical features (muscle size) and the exercises they may perform to increase hypertrophy. Jump distance is a measure of leg strength; thus, the longer the distance jumped the greater the leg strength. Males’ leg strength could be due to involvement in other activities/sports/fitness endeavors that inadvertantly—or intentionally—increase
leg strength. Within the subcomponents that the PSPP encompassed, physical strength was one that was assessed. Scoring higher on this specific subcomponent could attribute to males feeling they are stronger or bigger in musculature than their peers, so they will perceive themselves as more fit, which explains the correlation existing between PMC, jump max and push-ups in males.

When MC and HRF were considered as a total construct and the total sample was included in the analysis (Table 6), strong, positive correlations are present between MC index, HRF index, and PSPP score. These findings agree with other studies that have examined MC and HRF from a “total construct” perspective rather than by individual skills (Barnett et al., 2008; Luz et al., 2017; Stodden et al., 2009; Stodden et al., 2012; Wang et al., 2013). However, these results are different from Haga et al. (2015), who found that the MC/HRF relationship declines with age. Researchers used 194 children and adolescents. Motor ability was assessed in children using the Movement Assessment Battery for Children-2 (MABC-2). Adolescents’ MC was assessed using measures of manual dexterity, assessing speed and sureness, coordination, hand-eye coordination, accuracy of catching, accuracy of hitting a target, and static and dynamic balance. For fitness, the standing broad jump was used to assess explosive strength, running 20-meters was used to assess speed, and the Reduced Cooper Test was used to analyze endurance. Authors found a significantly lower correlation between MC and HRF in the adolescent group (15-16 years) compared to the younger age group, indicating that the strength of the MC/HRF relationship declines with age. The mode of testing could have attributed to these findings due to the fact that the MABC and MABC-2 focus more on balance, postural stability and
coordination, while the current study used scores of maximum efforts of throwing, kicking and jumping.

For females in the sample, there were no significant correlations between MC index, HRF index, and PSPP total score. However, the sub-sample of women was very small ($n = 18$) and the results were likely not statistically powerful enough to elicit relationships when the MC and HRF variables were combined to form an index. For males in the sample, the only significant correlation was between PSPP total score and HRF index ($r = .355$, $p < .05$). It is not surprising that males who have higher physical perceptions of themselves also are highly physically fit. Males tend to put emphasis on hypertrophy and muscle strength when they exercise which can be seen in their outward appearance. So, for a male to have higher perceptions of their physical strength and attractiveness, which were constructs within the PSPP, it makes sense that the same male would have a physical figure that aligns with his self-perceptions. However, males’ overall PMC was not related to the MC index. Gross MC is not a characteristic that can be observed via physique, unlike physical fitness or strength. It is difficult to assume that a person has good MC based on their physical appearance compared to assuming physical fitness. The non-association between MC index and PSPP could be attributed to the notion that males who are more fit have higher perceptions of themselves compared to males who are highly skilled. These findings agree with Vedul-Klelsás, Sigmundsson, Stensdotter, and Haga (2012), who found that PMC was more strongly correlated to HRF than MC in their sample of males. Their study consisted of 6th grade children ($n = 67$) who completed the MABC for motor skill testing, Self-Perception Profile for Children to measure PMC, and the Test of Physical Fitness. They suggested that time spent being physically active
could be positively related to self-perception of physical fitness, thus with males being more physically active this will increase their HRF scores while also increasing their PMC scores.

The study was not without limitations. The sample was comprised exclusively of Physical Education and Coaching majors at SUNY Cortland, so participants’ performance on the variables that were measured may not be representative of the general population. Though our data suggest that the relationship between MC, HRF, and PMC exists in young adulthood, these findings cannot be confirmed without longitudinal data. Future research should consider including a young adult sample in longitudinal studies of this nature, as the few longitudinal studies that exist only track MC, HRF, and PMC in childhood. It would also be important to examine the MC/HRF/PMC relationship in young adults from fields other than Physical Education and Coaching.

**Conclusion**

In summary, our study indicates that there are relationships between MC, HRF, and PMC in a college-aged sample, but that these relationships are expressed differently depending on sex, individual skills, and the type of measurement used. As expected, males performed better than females in all aspects of MC and HRF with the exception of sit-ups. Males also scored higher on the PSPP questionnaire and showed more correlations among the various variables compared to females. There was an interesting inverse correlation between sit-ups and throwing for females in the sample, possibly suggesting that women devote exercise time exclusively to skill-based endeavors (e.g., ballistic skills) or fitness-based endeavors that indirectly increase abdominal strength/endurance. The only significant, positive correlations for females were between sit-ups and push-ups, and push-
up and jumping. There were no significant correlations for females between PMC and MC or PMC and HRF. Males’ HRF was significantly correlated to their PMC, indicating that men who perceived themselves as being physically competent were actually competent.

Overall, our findings suggest that MC, HRF, and PMC are related in a college population.
REFERENCES


Appendix A - IRB LETTER OF APPROVAL

MEMORANDUM

To: Samantha Moss
    Larissa True

From: John Foley, Reviewer on behalf of
      Institutional Review Board

Date: 2/23/2018

RE: Institutional Review Board Approval

In accordance with SUNY Cortland’s procedures for human research participant protections, the protocol referenced below has been approved for a period of one year:

Title of the study: Relationships among Actual Motor Competence, Perceived Motor Competence and Health-Related Fitness in a College-Aged Population

Level of review: Expedited

Protocol number: 17/1837

Project start date: Upon IRB approval

Approval expiration date*: 2/22/2019

* Note: Please include the protocol expiration date to the bottom of your consent form and recruitment materials. For more information about continuation policies and procedures, visit www.cortland.edu/irb/Applications/continuations.html

The federal Office for Research Protections (ORHP) emphasizes that investigators play a crucial role in protecting the rights and welfare of human subjects and are responsible for carrying out sound ethical research consistent with research plans approved by an IRB. Along with meeting the specific requirements of a particular research study, investigators are responsible for ongoing requirements in the conduct of approved research that include, in summary:

- obtaining and documenting informed consent from the participants and/or from a legally authorized representative prior to the individuals’ participation in the research, unless these requirements have been waived by the IRB;
- obtaining prior approval from the IRB for any modifications of (or additions to) the previously approved research; this includes modifications to advertisements and other recruitment materials, changes to the informed consent or child assent, the study design and procedures, addition of research staff or student assistants, etc. (except those alterations necessary to eliminate apparent immediate hazards to subjects, which are then to be reported by email to irb@ cortland.edu within three days);
- providing to the IRB prompt reports of any unanticipated problems involving risks to subjects or others;
- notifying the IRB of continued research under the approved protocol to keep the records active; and,
- maintaining records as required by the HHS regulations and NYS State law, for at least three years after completion of the study.

Miller Building, Room 206 • P.O. Box 2000 • Cortland, NY 13045-0900
Phone: (607) 753-2511 • Fax: (607) 753-5995
In the event that questions or concerns arise about research at SUNY Cortland, please contact the IRB by email irb@cortland.edu or by telephone at (607)753-2511. You may also contact a member of the IRB who possesses expertise in your discipline or methodology, visit http://www.cortland.edu/irb/members.html to obtain a current list of IRB members.

Sincerely,

[Signature]

John Foley, Reviewer on behalf of
Institutional Review Board
SUNY Cortland
Informed Consent Document  
Student Researcher: Samantha Moss  
Faculty Supervisor: Larissa True

The current research that you are asked to participate in is completely voluntary. I request your informed consent to be a participant in the study explained below:

**Purpose:** The purpose of this study is to examine the interrelationship of perceived motor competence, motor competence and health-related fitness in a college-aged population.

**Procedures:** As a participant in the current study, you will be asked to report to the SUNY Cortland Lusk Fieldhouse for testing for approximately 1-2 hours. Participants will be asked to self-report age, sex, height and weight on a confidential document. You will then be asked to complete a Physical Self-Perception Profile (Revised) document. This will indicate how low or high you perceive yourself doing certain tasks as well as how you feel about yourself. This document is also completely confidential to only the research team. Once the documents are filled out, a series of motor competence testing will take place. You will be asked to overhand throw a tennis ball as hard as you can into a net for a total of three times. Your speed will be recorded for each time using a radar gun. Then, you will be asked to kick a soccer ball as hard as you can into a net for a total of three times. Your speed will be recorded for each time using a radar gun. To complete the MC testing, you will be asked to stand at the base of a tape measure and long jump as far as possible for a total of three times, landing on both feet. Your distance will be recorded for each time using the tape measure. For the health-related fitness testing portion, you will be asked to complete a push-up test. This will consist of a 2-minute period where you would perform as many successful push-ups as possible. The test is complete once form is broken or the participant quits. After, you will be asked to complete a timed plank. You will be directed on your hands to maintain a parallel stature to the floor for as long as possible and your final time will be recorded. The test is complete once form is broken or when you decide to quit. Lastly, participants are asked to complete a Beep Test. Starting at one end of a 20-meter distance, a loud “beep” will echo signaling participants to run to the opposite end of the 20-meter distance. Once the participant cannot get within 2 meters of the line, the test is complete and total laps will be recorded for analysis.

**Risks:** Extreme caution will be used during the testing periods to ensure that each participant is safe throughout. The primary risks that can be involved during the testing procedures are soreness, light-headedness, muscle fatigue, or nausea. These risks are similar to a period of exercise.

**Benefits:** This study could indicate what kind of relationship lies between PMC, MC and HRF in college students and how one impacts the other based upon test scores.

**Freedom to Withdraw:** Participants in this study can withdraw from the study at any time for any reason without any consequence, penalty or impact on your grade. There will not

SUNY Cortland IRB  
Protocol Approval Date: 2/23/2018  
Protocol Expiration Date: 2/22/2019
There are no negative interactions from the researchers, Kinesiology Department at SUNY Cortland or faculty advisors for this study.

**Contact Information:** Any other comments, questions or concerns please contact Samantha Moss (631-672-0263 or Samantha.moss02@cortland.edu). This study has been approved by the Institutional Review Board at SUNY Cortland. For more information about research at SUNY Cortland or information about the rights of research participants, please contact the Institutional Review Board (607-753-2511 or irb@cortland.edu)

I have read and understand the description of the current study and consent to participate:

________________________
Printed Name of Participant

________________________    ______________
Signature of Participant          Date

SUNY Cortland IRB
Protocol Approval Date: 2/23/2018
Protocol Expiration Date: 2/22/2019
### Physical Self-Perception Profile (Revised)

Below are statements that allow people to describe themselves. There are no right or wrong answers. For each statement, circle if it is “very untrue” (1), “somewhat untrue” (2), “somewhat true” (3), or “very true” (4) for you.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Very Untrue</th>
<th>Somewhat Untrue</th>
<th>Somewhat True</th>
<th>Very True</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am not so confident when I take part in sports activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. I tend to feel a little uneasy in fitness and exercise settings.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I am extremely confident about my body’s appearance.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. When a situation requires strength, I am among the first to step forward.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. I feel extremely satisfied with the kind of person I am physically.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. Given the chance, I am always among the first to join in sports activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I am very confident about my ability to exercise regularly and maintain my physical condition.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. I do not feel that my body looks like it is in good physical shape compared to most people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. I feel that I am physically stronger than most people of my sex.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. When it comes to the physical side of myself, I do not feel</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. I am sometimes slower than most when I learn a new sports-related skill.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. I do not feel confident about my level of physical conditioning and fitness.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. I feel that I have difficulty maintaining an attractive body.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14. I feel that I am very strong and have well-developed muscles compared to most people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15. I wish that I could have more respect for my physical self.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16. I feel like I am among the best when it comes to athletic ability.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17. I do not usually have a high level of stamina and fitness.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18. I feel that I have an attractive body compared to most people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19. I feel that most people are better than me when dealing with situations requiring strength.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20. I almost always feel very proud of who I am and what I can do physically.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>21. I do not feel I am very good at playing sports.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>22. I feel that I always maintain a high level of physical conditioning compared to most people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>23. I feel embarrassed by my body when I wear few clothes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>24. I feel that my muscles are much stronger than most others’ of my sex.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>25. I am sometimes unhappy with the way I am or what I can do physically.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>26. I feel that I am always among the best when it comes to joining in sports activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>27. I make certain I take part in some form of regular, vigorous physical exercise.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>28. I feel that I am often admired because my body is considered attractive.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>29. I tend to lack confidence when it comes to my physical strength.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>30. I always have a very positive feeling about the physical side of myself.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>