RELATIONSHIP BETWEEN COUNTER MOVEMENT JUMP PERFORMANCE AND EXTRAVERSION LEVEL

by

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ABSTRACT

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Introduction: Sport psychology literature has demonstrated a relationship between personality and physical ability and athletic performance. In general, individuals who exhibit a greater degree of extraversion display a greater physical ability and athletic performance than individuals who exhibit a lower degree of extraversion. The physiology literature has also demonstrated relationships between extraversion level and movement time and electrophysiological mechanisms (i.e., muscle activity) during a fine movement task. However to date, no study has investigated if these physiological relationships manifest themselves during a gross movement task. If a relationship exists, it may provide mechanistic reasoning behind the previously observed relationships between personality and physical ability and athletic performance. As such, the primary purpose of this study was to investigate the relationship between counter movement jump (CMJ) performance and personality. The secondary purpose was to investigate possible electrophysiological mechanisms (i.e., peak muscle activity) to further explain the relationship between CMJ performance and personality. **Methods:** This study examined the relationship between peak height, peak power output, peak force output, and peak

velocity during the CMJ of 25 participants. Performance of the CMJ was examined through the use of a Myotest Sport unit. Peak muscle activity during the CMJ was also examined through the use of surface electromyography (EMG). EMG was utilized to determine if a relationship existed between extraversion level and agonist (quadriceps) and/or antagonist (hamstrings) muscle activity during the CMJ. All measures of personality were assessed via the Eysenck Personality Inventory (EPI). Bivariate Pearson correlations were used to examine the relationships among all tested variables.
Results: Extraversion and neuroticism level were not significantly correlated to any of the CMJ performance measures. Extraversion level was not significantly correlated to any of the peak muscle activity in the right or left legs during the CMJ. Neuroticism level was only significantly related to peak muscle activity of the right semitendinosus (ST) during the CMJ. All other muscle activity correlations were not statistically significant. **Conclusions:** Personality does not appear to be significantly related to CMJ performance. However, a relationship between neuroticism level and peak muscle activity during the CMJ may exist, and further investigation is warranted.

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CHAPTER I: INTRODUCTION

Background

Athletic performance and physical ability have been studied and quantified by researchers for decades. Throughout the years, researchers have developed numerous variables that help explain and predict performance. These measures are generally either psychologically or physiologically based. Typical psychological measures of interest include mood states, arousal level, ability to concentrate, and personality. Common physiological measures include maximal oxygen uptake (VO_{2max}), muscle fiber type, level of muscle glycogen stores, maximal strength, and power output. Despite the abundance of literature within each individual area (i.e., sport psychology or sport physiology), these two bodies of literature have advanced independent of each other. Thus, there is an opportunity for research studies to simultaneously examine the potential for mutual contributions of physiological and psychological factors to athletic performance.

In the sport psychology literature, several relationships have been identified between personality and physical ability, as well as personality and athletic performance. Specifically, the personality trait of extraversion has been widely investigated. Extraversion is conceptualized on a continuum, where extraverted individuals exhibit a high degree of extraversion and introverted individuals exhibit a low degree of extraversion. Extraverts tend to be more impulsive, active, outgoing, and responsive, while introverts tend to be more calm, careful, passive, and reserved (H.J. Eysenck, 1963).

The sport psychology literature has routinely demonstrated that individuals with a higher level of extraversion engage in more physical activity and display greater physical ability than individuals who exhibit a lower level of extraversion (Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965). The literature also demonstrates that elite level athletes exhibit a high degree of extraversion when compared to their less proficient counterparts (Briggs, Sandstrom, & Nettleton, 1979; Morgan & Johnson, 1978; Morgan, O'Connor, Ellickson, & Bradley, 1988). Thus, extraversion appears to be an important component of athletic performance.

The sport psychology literature has also demonstrated that the personality trait of neuroticism is negatively correlated with sport performance (Morgan et al., 1988; Raglin, 2001). Highly neurotic individuals "tend to be emotionally over-responsive and to have difficulties in returning to a normal state after emotional experiences" (H.J. Eysenck & Eysenck, 1968, p. 6). The research demonstrates that when competing at the same task or sport, an athlete who displays a high degree of neuroticism is generally less successful as an athlete who exhibits a low degree of neuroticism (Morgan et al., 1988). Due to their inherent relationship to each other, the personality traits of extraversion and neuroticism are often examined concurrently. To mitigate this possible conflicting factor, steps must be taken to control for neuroticism level when specifically examining the relationship between the personality trait of extraversion and sport performance.

The sport physiology literature has demonstrated several relationships between extraversion and very specific measures of performance. This research has primarily examined these relationships through the electrophysiological parameters of movement. The literature has demonstrated possible, although debatable, relationships in the speed of central cognitive processing and level of extraversion (Stahl & Rammsayer 2004; Stahl & Rammsayer 2008; Wilson, 1990). That is, the more extraverted the individual is, the faster central cognitive processing speed during a reactionary task. In addition, there is evidence in the literature demonstrating that individuals who exhibit a high degree of extraversion display a decreased motoneuronal excitability and a faster movement time (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000; Pivik, Stelmack, & Bylsma, 1988; Stelmack & Pivik, 1996).

More recently, the literature has suggested possible differences in muscle activity levels between individual in different personality groups during functional movements and during the loading of a joint (Chany, Parakkat, Yang, Burr, & Marras, 2006; Glasscock, Turville, Joines, & Mirka, 1999; Marras, Davis, Heaney, Maronitis, & Allread, 2000). These types of functional movements include the loading of a single joint (e.g., elbow) as well as gross loading of the spine (e.g., occupational lifting). The differences in functional loading and movements have been attributed to differences in muscle activation patterns during these tasks. These findings suggest that personality type, previously identified in the sport psychology literature as meaningful relative to overall physical ability and general athletic performance, may also have a relationship with specific measures of muscle physiology and function.

While, the aforementioned research suggests that there may in fact be a psychophysiological link between personality and physiological factors of performance, these two avenues of research have rarely converged. Due to these bodies of literature remaining in isolation from each other, the functional or mechanistic reasoning that creates personality-based differences in performance during an athletic activity has not been investigated. Athletic events routinely require gross, powerful movements such as, pushing, pulling, kicking, and/or jumping. Little, if any, research has been conducted to determine if the observed physiological relationships with extraversion manifest in power-based tasks that are functionally more relevant to athletic performance (e.g., vertical jump), than the isolated movement tests done in previous studies. If so, this could provide mechanistic reasoning behind the overall athletic and physical ability performance differences observed in the sport psychology literature. As such, a gap in the investigation of possible psychophysiological links between extraversion and gross movement ability and functional performance exists in the literature.

Purpose

The primary purpose of this study was to investigate the potential relationship between counter movement jump (CMJ) performance (i.e., peak height, peak power, peak force, & peak velocity) and personality (i.e., extraversion & neuroticism). A secondary purpose included follow-up analyses to examine possible electrophysiological mechanisms in order to further explain the relationship between CMJ performance and personality. These mechanisms were investigated by examining peak muscle activity level during the CMJ, through the use surface electromyography (EMG). This study was the first of its kind to investigate relationships between personality measures and power production and electrophysiological measures during a gross movement task. This study will contribute to the literature by investigating possible psychophysiological links between personality and gross physiological performance.

Hypotheses

The primary hypothesis of this study was that the personality trait of extraversion would be positively correlated to peak height, peak power production, peak force output, and peak velocity during the most proficient CMJ. It was also hypothesized that extraversion would be positively correlated to muscle activation in the agonist muscles (quadriceps) and negatively correlated to the antagonist muscles (hamstrings) during the propulsion phase of the most proficient CMJ. It was hypothesized, that if extraversion level was significantly correlated to CMJ performance, these EMG measures would help identify the possible mechanistic reasoning associated with this relationship.

Significance

Scientific Significance. The scientific significance of this study is that it was the first of its kind to investigate a possible relationship between physical performance during a gross movement task (i.e., the CMJ) and personality (i.e., extraversion & neuroticism). In addition, this study was the first to investigate a relationship between power production and velocity during a gross movement task and extraversion. This study also examined a possible relationship between muscle activation during a gross movement task and extraversion level through the use of surface EMG. These EMG measures were utilized to help identify possible mechanistic reasoning to further explain performance outcomes.

Practical Significance. The practical significance of this study is that it was the first of its kind to investigate a possible functional and mechanistic relationship between CMJ performance and personality. This study contributed to the gap in the literature in relation to understanding if measures of personality are related to physiological and mechanistic factors during a gross movement task. This study also contributed possible mechanistic reasoning that identified relationships between physiological characteristics and performance during a gross, functional movement. These mechanistic relationships can contribute to the fields of strength and conditioning as they identify possible factors related to a performance during a gross movement task. These mechanistic relationships can also contribute to the fields of physical therapy and rehabilitation as they demonstrate physiological characteristics that are related functional movement.

Delimitations

In order to control for gender differences in extraversion and neuroticism levels, and to stay in accordance with the previous literature, this study only examined female participants (Lynn & Martin, 1997). In order to control for changes in the level of neuroticism during the aging process, all participants were between 18-29 years of age (H.J. Eysenck & Eysenck, 1968). To eliminate the skewing of the data due to some individuals simply being more physically active and thus, in better physical condition than others, only participants that engage in regular physical activity and meet the American College of Sports Medicine's (ACSM) weekly physical activity level were included. In addition, to minimize the risk of injury, individuals that are taking prescribed medication for a symptomatic illness, had an injury, surgery, or bone abnormalities on their knees, hips, or ankles, have a heart condition or any chest pain, are pregnant, suffer from dizziness, and/or have hearing impairments (due to an auditory stimulus being used), were not allowed to participate in this study. Therefore, the findings of this study will not be generalizable beyond this specific sample, and future will research will be needed to make more broad, generalizable conclusions.

Assumptions

This study made the following assumptions: (a) participants accurately and honestly answered the Criteria for Inclusion Questionnaire and the Eysenck Personality Inventory (EPI); (b) participants did in fact engage in the required level physical activity per week; (c) participants refrained from smoking (or any other tobacco product) and caffeine intake the four hours, as well as any heavy resistance training the 48 hours preceding Phases 1-3; and (d) participants did provide maximum effort during the CMJ.

Limitations

Major limitations of this study were possible equipment error due to interference between the EMG electrodes and possible experimenter error when conducting the various physiological measurements. Possible participant error may also exist during completion of the EPI questionnaires.

CHAPTER II: LITERATURE REVIEW

Introduction

The psychology of athletic performance and physical activity is an area of research that has seen tremendous growth in recent years. In addition, research on physiological mechanisms that influence athletic performance, physical ability, or functional performance has also sustained tremendous growth. However, these two areas of research appear to have advanced in relative isolation to each other.

In the sport psychology literature, several relationships have been identified between personality and physical ability, as well as personality and athletic performance. Specifically, the personality trait of extraversion has been widely investigated. The physiology literature has also demonstrated several relationships between extraversion and various measures of performance.

To this end, the review of the literature that follows will first define the personality trait that is being investigated (i.e., extraversion), and confirm the reliability and validity of the Eysenck Personality Inventory (EPI) which is often used to assess this trait. The review will also highlight the research demonstrating that physical ability and overall physical activity level is significantly related to the level of extraversion an individual possesses, which may explain why elite level athletes generally display a greater degree of extraversion than their less proficient counterparts.

Subsequently, the review will demonstrate the psychophysiological nature of extraversion by offering an argument that the observed electrophysiological differences associated with extraversion level can ultimately explain the performance and ability level differences seen in the sport psychology literature. Finally, this review will reveal the current gap in the literature linking the possible underlying physiological mechanisms that result in the observed athletic and physical ability differences. An argument will be made that the relationship between extraversion level and performance measures should be further investigated during an athletically dynamic, functional movement.

Eysenck's Theory of Personality

The possible link between performance outcomes and personality characteristics (i.e., type, traits, states) has been widely studied in the sport psychology literature. Previous research has examined Type A/B personalities, mood states, and extraverted/introverted personalities in relation to overall sport performance, specific task performance, and general physical activity level (Morgan, O'Connor, Ellickson, & Bradley, 1988). The literature generally suggests that there is a difference in performance outcomes across these different personality factors. However, a substantial number of studies exist that have reported equivocal results, involved poor methodology, or resulted in limited practical application of the respective assessment measure.

A commonly researched personality variable that has demonstrated links to possible physiological mechanisms in performance differences is the trait of extraversion. While extraversion is conceptualized on a continuum, in order to study differences across individuals, the level of extraversion is often broken down into two categories: (a) extraverts, who exhibit a high degree of extraversion; and (b) introverts, who exhibit a low degree of extraversion.

One of the pioneers of the extraversion research was H.J. Eysenck, who theorized that there was a physiological link to the psychological parameters of extraverts and introverts. During the course of Eysenck's research, it was determined that there are several traits that have come to define the two personality groups. Extraverts tend to be more impulsive, active, outgoing, and responsive, while introverts tend to be more calm, careful, passive, and reserved (H.J. Eysenck, 1963). A number of these characteristics pertain to an actual physical movement-related outcome (i.e., active, responsive, impulsive), thus a link to the psychophysiological nature of extraversion may exist.

Eysenck hypothesized that introverts naturally have a higher level of cortical excitation than extraverts (H.J. Eysenck, 1963). Conversely, extraverts have a higher level of cortical inhibition than introverts. This is the framework for defining extraverts as *sensation-seekers* and introverts as *sensation-avoiders*. Theoretically, extraverts participate in sensation-seeking behavior in order to raise their cortical arousal level and introverts avoid this type of behavior because their cortical arousal level is naturally high. If extraverts prefer engaging in sensation-seeking behavior, this may possibly explain how elite athletes also tend to be more extraverted.

Eysenck further postulated that the ascending reticular formation may be the structure in the central nervous system (CNS) that is responsible for these individual differences in excitation and inhibition (H.J. Eysenck, 1963). Specifically, he hypothesized that the ascending reticular activation system (ARAS) may be the major distinguisher due to its role in cortical facilitation. This hypothesis evolved into the Eysenck Theory of Personality and led to the development of the EPI. In time, extraversion and its psychophysiological outcomes would explode into several different avenues of research.

Eysenck's Personality Inventory. In order to properly assess an individual's level of extraversion and neuroticism, an accurate and reliable assessment was created.

H.J. Eysenck and Eysenck (1968) developed the EPI based on the assertion that most of the traits that make up personality can be reduced to two factors: Extraversion-Introversion and Neuroticism-Stability. The Extraversion-Introversion factor creates the Extravert and Introvert groups based upon an individual's level of Extraversion (E). According to the personality scholars H.J. Eysenck and Eysnck (1968) the typical extravert is:

> Sociable, likes parties, has many friends, needs to have people to talk to, and does not like reading or studying by himself. He craves excitement, takes chances, often sticks his neck out, acts on the spur of the moment, and is generally an impulsive individual. He is fond of practical jokes, always has a ready answer, and generally likes change. He is care-free, easygoing, optimistic, and likes to 'laugh and be merry.' He prefers to keep moving and doing things, tends to be aggressive and to lose his temper quickly. His feelings are not kept under tight control and he is not always a reliable person (p. 6).

According the same personality scholars (H.J. Eysenck & Eysenck, 1968), the typical introvert is:

> A quiet, retiring sort of person, introspective, fond of books rather than people; he is reserved and distant except to intimate friends. He tends to plan ahead, 'looks before he leaps,' and distrusts the impulse of the moment. He does not like excitement, takes matters of everyday life with proper seriousness, and likes a well-ordered mode of life. He keeps his feelings under close control, seldom behaves in an aggressive manner, and does not lose his temper easily. He is reliable, somewhat pessimistic, and places great value on ethical standards (p. 6).

However, the Extraversion-Introversion factor is only one half of Eysenck's Theory of Personality. The other factor, the Neuroticism-Stability factor, describes the level of Neuroticism (N) an individual displays. Individuals scoring high in N "tend to be emotionally over-responsive and to have difficulties in returning to a normal state after emotional experiences" (H.J. Eysenck & Eysenck, 1968, p. 6). The higher level of N, the more emotional liability and over reactivity an individual displays. According to Eysenck's theory, the Extraversion-Introversion and the Neuroticism-Stability factors intersect to form four groups of individuals: Melancholic, Phlegmatic, Choleric, and Sanguine. These groups and factor scales, along with corresponding personality traits, can be seen in Figure 1.

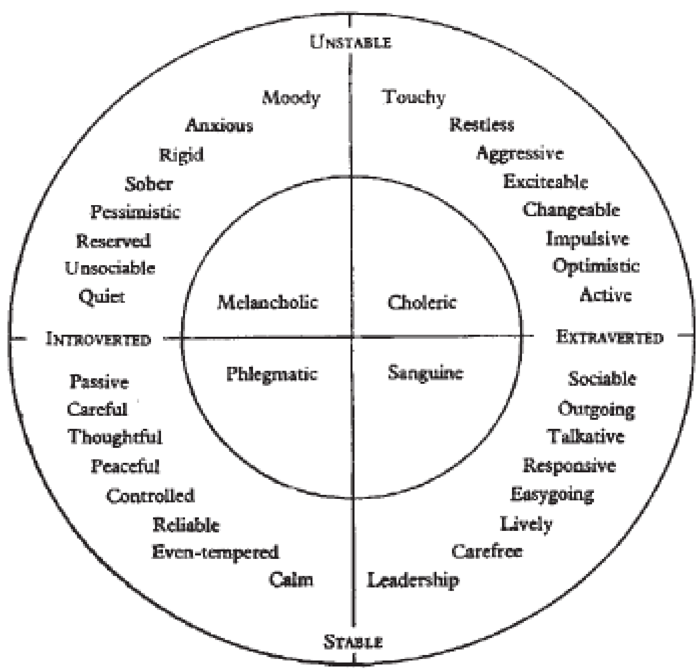

Figure 1. Eysenck's Theory of Personality. Adapted from "Biological basis of personality" by H.J. Eysenck, 1963, *Nature, 199,* p. 1032.

Using this theory, Eysenck created the EPI. The final version of the EPI contains 57 questions and three scales: extraversion, neuroticism, and lie. According to the normative data published in the *Manual of the Eysenck Personality Inventory*, the normal population (n = 1931) reported a mean extraversion score of 14.2 (±3.9) and a mean neuroticism score of 10.5 (±4.7) for Form B of the EPI (H.J. Eysenck & Eysenck, 1968). In contrast, scores for one of the most commonly studied groups (i.e., American students) are higher than those of the general population. Specifically, the American students sample group (n=1003) reported a mean extraversion score of 15.2 (±3.5) and a mean neuroticism score of 11.4 (±4.8) for Form B of the EPI (H.J. Eysenck & Eysenck, 1968).

The validity of the EPI was established by comparing the EPI to other personality questionnaires and inventories. For example, the neuroticism scale of the EPI is significantly correlated with Catell's anxiety factor (SAF) and neuroticism factor (NSQ) with values of r = 0.70 and r = 0.42, respectively (H.J. Eysenck & Eysenck, 1968). These significant correlations to the normative values of other personality assessments demonstrate that the EPI is similar to other validated personality assessments. This observed reliability, coupled with the fact that the EPI only examines these two personality traits and not a plethora of other traits, has made the EPI one of the most used assessment tools when investigating extraversion and/or neuroticism (Stelmack, 1990).

Extraversion/Neuroticsim and aging. In addition to publishing normative data for the general population and for American students, the *Manual of the Eysenck Personality Inventory* (H.J. Eysenck & Eysenck, 1968) includes data demonstrating a slight, yet significant, decline in extraversion (r = -0.24) and neuroticism (r = -0.16) levels as an individual ages. While explanation for the aforementioned decline is speculative, H.J. Eysenck (1963) hypothesizes it may be due to a decrease in the excitation and/or inhibition capabilities of the ARAS associated with the aging process.

Extraversion/Neuroticism and gender. The *Manual of the Eysenck Personality Inventory* also suggests that gender differences in levels of extraversion and neuroticism may exist, however, that future research was needed to confirm (H.J. Eysenck & Eysenck, 1968). As a result, Lynn and Martin (1997) examined possible differences in extraversion and neuroticism levels between men and women. Results of their study suggest that men were, on average, significantly more extraverted than women ($p < 0.05$). Results of their study also suggest that women were significantly more neurotic than men ($p < 0.05$). As such, gender differences should be taken into account in the methodology of future studies.

Extraversion and Physical Ability and Physical Activity Level

During the development of the EPI, physiological differences between extraverts and introverts became apparent to H.J. Eysenck and others. The review paper, Eysenck, Nias, and Cox (1982) describes differences in athletic ability and physical activity between extraverts and introverts. Eysenck at al. (1982) explains that extraverts tend to be more proficient at sports and athletics than introverts, and that most elite athletes are generally more extraverted than the general population. This newly discovered relationship between athletic performance and extraversion has opened up a new avenue of research investigating a possible link between physiological performance and personality.

Eysenck et al. (1982) also explains that extraverts tend to be more physically active than introverts, prompting several questions to be raised regarding extraversion level and physical activity. If individuals with a high extraversion level routinely engage in more physical activity, the variable prompting the relative influence can be questioned.

In other words, does participating in exercise or physical activity cause someone to become more extraverted?

Extraversion and physical ability. J.E. Kane (1964) was one of the first researchers to examine the relationships between physique, physical abilities, and personality factors. In a study of 412 boys (mean age = 14 years) the physical conditions of strength, skills, linearity, and muscularity, as well as the societal factor of sociometric status, were assessed. The researchers also assessed the personality profile of the subjects through the use of the Cattell Sixteen Personality Factor Questionnaire (Cattell 16PF), and specifically examined the levels of extraversion and stability that were identified from the 16PF. Although methodological details are vague, this study was one of the first to investigate this topic and therefore worth discussion in this review.

Results of the Kane (1964) study suggest that physical abilities are significantly related to the personality trait of extraversion. Specifically, motor ability ($r = 0.40$, $p = 0.05$) and total skill ability ($r = 0.52$, $p = 0.01$) were all significantly correlated to extraversion. Kane concluded that extraversion level is significantly related to competitive skills ability and general motor ability. However, extraversion level was not significantly related to static strength. This conclusion may suggest that extraverts were not simply stronger than their counterparts, but exhibited more proficient specific skill sets and motor function ability. Kane ultimately developed two hypotheses that questioned the physiological link to extraversion: (a) Does a high level of physical activity increase the development of extraversion?; and (b) Are individuals who possess a high level physical ability simply more extraverted than their less proficient counterparts?

To answer these questions, Kane (1970) created six groups (3 groups of males and 3 groups of females) of 100 subjects each, who were divided by athletic ability (i.e., Specialist Physical Education Students, General Students, Total). Personality was assessed via the Cattell 16PF, while physical ability structures were assessed via general fitness scores and anthropometric measurements. Among men, extraversion was significantly related to general athletic ability (no reported *r* or *p*-values). Explosive strength was related to stability, and muscularity and sports participation were related to toughmindedness. These results are worthy of attention as stability and toughmindedness are factors of overall extraversion. Among women, a weaker relationship was found, but no significant differences in personality between physically gifted men and women were demonstrated. Toughmindedness was still related to general athletic ability among women. Levels of significance were not reported for these values, although a significant difference in personality between physically gifted students and general students for both men and women was noted. Multiple correlational analyses were also calculated and showed significant ($p < 0.001$) correlations between extraversion and physical attributes for each group (no reported *r*-values).

In an attempt to determine if physical involvement has an impact on personality, subjects were reassessed via the Cattell 16PF three years later. When comparing the scores of the previous test to the scores of this second test, no significant differences in the personality variables were found for all the groups (Kane, 1970). As such it was determined that: (a) participation in sports and physical activity has no effect on personality (i.e., extraversion, stability [neuroticism]); and (b) individuals who exhibit a high level of physical ability also display a high level of extraversion.

Effect of physical activity on extraversion. Although these studies conducted by Kane (1964; 1970) have limitations and methodological flaws, a framework for future research was established. In the first of a two-part study investigating the relationship between physical activity and personality, 386 high school junior and senior boys completed three personality tests: the A-S Reaction Study of Allport, the Cattell 16PF, and the Kuder Preference Record (Tillman, 1965). The subjects also completed an 'overall' physical fitness test that consisted of pull-ups and the 600 yard run, and were subsequently split into a high physical fitness group and a low physical fitness group. The high physical fitness group exhibited more dominance and was considered more extraverted, socially-oriented, and interactive than the low physical fitness group. Additionally, the low physical fitness group appeared to favor accuracy and precision, and was considered to be more introverted and tense than the high physical fitness group. Although these personality tests did not specifically measure the level of extraversion, the high physical fitness group exhibited significant differences in the Liveliness factor (F) and the Affiliative factor (Q_2) of the Cattell 16PF. Thus, the high physical fitness group was pictured as being more extraverted than the low physical fitness group.

In the second part of the study (Tillman, 1965), the lower physical fitness group was divided into an experimental group ($n = 26$) and a control group ($n = 24$). The experimental group's physical education class for the year (roughly 9 months) became a structured, high intensity, physical fitness program. The control group participated in the normal, general physical education class. At the end of the year, both groups were re-evaluated in the fitness and personality tests. Although the physical fitness scores for both steps improved, the scores for the experimental group improved significantly more than the scores for the control group. Only 1 of the 28 personality trait factors changed significantly in the experimental group at the end of the training, and no factors changed in the control group. These results provide more evidence demonstrating that physical activity does not alter a person's personality and that personality remains stable during the course of training time.

Extraversion and physical activity level. Hendry (1975) conducted another study that investigated the link between personality and physical activity. A convenience sample of 96 men and 134 women enrolled in a college psychology course took the EPI and the Attitude to Physical Activity Scale, their socioeconomic class was determined, and their academic work in the class was assessed. Subjects also provided information on the quantity and competitiveness of their normal physical activity level. Researchers then classified the subjects into three groups (active-competitively, active-recreationally, or non-participant) based on the subjects' physical activity level and type of sport (i.e., competitive university athlete, recreational athlete). Active subjects recorded a significantly ($p < 0.05$) higher level of extraversion in comparison to the non-participant group. Competitive subjects also had the highest average level of extraversion, although it was not significantly different than the recreationally active subjects. In addition, the active subjects in this study exhibited a higher level of extraversion when compared to previous 'normal population' norms published by Eysenck (1968). After a series of regression analyses, extraversion was found to have a significant positive correlation with physical activity ($p < 0.05$) in men, but not women. However, many of the correlations concerning women may have to be reexamined due to the changing of social norms and roles over time.

Summary. Based on these studies (Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965), it can be concluded that relationships exist between physical activity participation and extraversion, as well as between physical ability/performance level and extraversion. In addition, level of extraversion does not appear to change significantly as a result of physical activity level or stimulus. Due to these facts, extraversion is a valid and recommended personality characteristic to investigate when attempting to link personality to athletic performance.

Extraversion and Athletic Performance

As previously noted, there have been several studies (Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965) investigating possible relationships between personality factors and general physical ability skills and activity performance. However, the literature has also investigated personality factors that could possibly determine performance outcomes in elite athletes.

Prediction of performance. Briggs, Sandstrom, and Nettleton (1979) investigated the link between athletic performance and extraversion by attempting to accurately predict an athlete's 1500 meter run performance level (i.e., time) using several different prediction strategies: VO_{2max}, treadmill running time at 85% utilization of VO_{2max}, and level of extraversion. Ten male middle distance runners were used as subjects (ages 13-26 years, mean age = 17.6 years). Subjects first performed a graded VO_{2max} exercise test. Within seven days, the subjects ran on a treadmill for as long as they could at a speed that roughly elicited 85% of their VO_{2max}. All subjects were assessed with the EPI and the researchers also recorded the subject's personal record (based on self-recall) for running the 1500 meter race. Although this study had a small sample size and used young subjects, the average VO_{2max} was similar to other reported data of excellent middle-distance runners.

When analyzing the data, Briggs et al. (1979) found that extraversion level and 1500 meter run time were significantly correlated ($p < 0.05$), and that these two variables yielded the greatest correlation value ($r = -0.75$). Thus, the more extraverted the athlete, a shorter observed 1500 meter time. When the researchers analyzed the data via multiple correlations, the only significant ($p < 0.05$) multiple correlation was 1500 meter run time, VO_{2max}, and extraversion ($r = 0.77$). This research indicates that although obvious physiological parameters of performance exist, personality factors play an important role in athletic performance, and can even possibly predict the performance level of an athlete. The researchers suggested that due to the highly stressful nature of these tests and running events, extraverts may be able to better manage the stress and possibly better tolerate the pain associated with the race and/or training.

Personality and athletic performance was also investigated by Morgan and Johnson (1978), by investigating the correlation between personality characteristics and subsequent success rate of 57 oarsmen competing for 24 roster spots on the United States. Heavyweight ($n = 16$) and Lightweight Crew Team ($n = 8$). Although in Phase 1 of the study, the researchers investigated the overall personality structure of the competing oarsmen, Phase 2 and 3 are the most intriguing pieces of the study. In Phase 2, during the first day of the national training camp, the subjects were assessed via the Spielberger State-Trait Anxiety Inventory (STAI), the Somatic Perception Questionnaire (SPQ), the Profile of Mood States (POMS), and the EPI. The results of these surveys then created an overall construct that the researchers used to develop a prediction equation. This equation successfully predicted 13 of the 16 oarsmen (81%) that made the heavyweight crew team and had an overall prediction rate of 90%. Although the actual amount was not specifically noted by the authors, it was stated that extraversion accounted for the bulk of the discrimination in the discriminant function analysis.

In Phase 3 of the study, Morgan and Johnson (1978) used the same prediction equation for the 16 finalists competing for the lightweight crew team. This equation successfully predicted seven of the candidates (three to make and four to fail), but was not able to make predictions for all the candidates. The researchers concluded that the candidates for the lightweight crew team had a different personality structure than the candidates for the heavyweight crew team and thus, the need for two different personality constructs and prediction equations.

It must be noted that the prediction equation used in Morgan and Johnson (1978) also took into account all the other personality and psychological variables that the researchers were investigating. Due to this, it may be important to examine the extraversion differences and not the actual predictability of the equation itself. When comparing the data between the successful and unsuccessful oarsmen on the lightweight crew team, the successful oarsmen were significantly more extraverted ($p < 0.05$) than the unsuccessful oarsmen. There were also differences (although not significant) in extraversion seen in the successful (mean $E = 13.56$) and unsuccessful (mean $E = 11.28$) oarsmen on the heavyweight crew team as well.

The Iceberg Profile. Morgan et al. (1988) continued to investigate the links between personality characteristics and performance in elite distance runners through the use of the POMS. The POMS assesses the tension, depression, anger, fatigue, and confusion, and vigor levels of an individual. These characteristics are then grouped together creating a *global mood profile.* A higher total POMS score is equated to a higher (i.e., a more negative) global mood profile. The researchers determined that elite distance runners (along with many other types of athletes) consistently possessed a positive mood profile known as the *Iceberg Profile*. The *Iceberg Profile* is the below population average on tension, depression, anger, fatigue, and confusion, and higher than the population average on vigor. These total scores are also a more positive global mood profile than the population average. This is not different than other elite athletes, as athletes who possess a positive global mood profile are associated with higher performance levels than those who possess a negative mood profile.

Morgan et al. (1988) investigated the associations between several different personality variables and performance such as trait anxiety, extraversion, neuroticism, and global mood scores. The researchers found that there was a significant negative correlation between global mood and performance (r = -0.60). As the global mood profile increased (i.e., became more negative), performance decreased. This was the strongest correlation of the observed variables. Other examined significant correlations included neuroticism (r = -0.50) and trait anxiety (r = -0.56). Once again, as these variables increased, performance decreased.

Although Morgan et al. (1988) determined that global mood states are most related to performance, the usefulness of this measurement can be called into question. The POMS (and global mood states in general) is a state-related measure, and not a trait-related measure. The state psychological measure is a measure of the athlete's current mood state and not the athlete's overall, indigenous mood trait. Thus, it is difficult to compare or determine what success is across a whole group of athletes because the optimal level is individual specific. In addition, it is challenging to compare a performance measurement across a wider population base as these measures are only significant in the elite athletic population and not the general population. Also, these psychological variables are related to the athletes' overall performance and not any underlying physiological reasons that manifest a difference in performance. Due to these limitations, the other significant correlations that Morgan et al. (1988) observed are more interesting – neuroticism and trait anxiety.

Neuroticism and performance. Neuroticism and anxiety have been shown to be related to extraversion and the performance level of an athlete. Eysenck et al. (1982) stated that as the level of neuroticism increases, performance decreases. In addition, it has been observed that a person's overall level of neuroticism and anxiety decreases as the amount of regular exercise increases (Eagleton, McKelvie, & deMan, 2007). However, these negative correlations are not consistently observed, as the level of neuroticism appears to decrease with age and is typically at its highest during the late teenage years (Eysenck et al., 1982). Thus, neuroticism can be considered as a state personality variable, and not a trait personality variable. Due to these potential influences, the level of neuroticism an individual displays is something that must be accounted for in studies investigating extraversion and performance in young athletes.

Gravitational Theory. Based on these previous studies, extraversion appears to be consistent in not only distinguishing athletes and non-athletes, but even the performance level of athletes (Briggs et al., 1979; Morgan & Johnson, 1978; Morgan et al., 1988). More recent research has taken these findings a step further and used extraversion level as a way to distinguish the type of sport the athlete prefers or will potentially excel in. If there is a difference in the type of sport the highly extraverted athlete excels in, this may explain the conflicting results in the literature. The study Eagleton et al. (2007) separated 90 undergraduate students (45 first year students & 45 final year students) into three groups: team sport, individual sport, and non-participant. The personality profiles of the subjects were assessed via the EPI, and the subjects answered a questionnaire about the sport they participate in and the number of hours spent exercising per week. After completing an analysis of variance (ANOVA) between groups, the researchers found that subjects who participated in team sports were significantly more extraverted ($p = 0.001$) than subjects who participated in individual sports or no sport at all. In addition, the level of exercise did not significantly differ between individual and team sport participants, but the level of exercise of both groups was significantly higher than the non-participant group ($p = 0.001$). Also, an ANCOVA of extraversion with exercise time as a covariate indicated a significant effect due to sport ($p = 0.002$), but no significant effect due to year. This indicates that higher scores of extraversion in team sport subjects were independent of exercise time. This supports the conclusion of other studies (Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965) that exercise amount or stimulus does not shape or alter a person's level of extraversion.

However, more importantly, Eagleton et al. (2007) has shown that athletes who are more extraverted tend to participate more and be more successful in team sports than in individual sports. The researchers suggested that athletes who are more extraverted, are individuals who seek more arousal from activity; thus, team sports may be more attractive to these people than individual sports. This observation has been developed into the Gravitational Theory (Eagleton et al., 2007). When coupled with the previous research stating that the most successful athletes are significantly more extraverted than their less successful counterparts, another hypothesis may be formulated. That is, athletes with the highest level of extraversion are most likely going to participate in team sports, and be members of a competitive team (i.e., university, professional, etc.) as they are typically more successful. Eagleton et al. (2007) have seemingly demonstrated this, as the most extraverted subjects were members of a team sport for one of the university's competitive teams, and not simply a member of an intramural team. No significant difference was demonstrated because equal numbers of competitive and intramural athletes were not recruited across all categories as this study was not designed to investigate this hypothesis. However, the researchers state that participation rates in intramural versus competitive teams should be further investigated.

Summary. This line of research in the literature (Briggs et al., 1979; Eagleton et al., 2007; Morgan & Johnson, 1978; Morgan et al., 1988) has shown that not only are the most successful athletes typically more extraverted than their less successful counterparts, but that the extraverted athletes may excel more at specific types of sports. It remains unclear, what the physiological mechanisms are for such an observation or what explains why an extravert is more proficient at these types of sports than an introvert. It is possible that the explanation may be related to the psychological factors that coincide with the extraverted temperament (i.e., impulsive, active, outgoing, dominant, responsive) or that there are actual physiological differences between extraverts and introverts. It is interesting to note that H.J. Eysenck (1963) hypothesized all along that there may be physiological differences in the ARAS and other CNS structures that may explain these observed personality (and subsequent performance) differences.

Other researchers have suggested that these differences in athletic ability and function are a result of differences in physiological mechanisms between introverts and extraverts. The review paper Stelmack (1982) describes possible differences in central processing and/or peripheral sensory processing, spinal motoneuronal excitability, and expression of motor activity between introverts and extraverts. Stelmack further hypothesized that extraverts may be more proficient at gross motor activities and introverts may be more proficient at fine motor activities. These possible differences have created a new area of research related to the psychophysiology nature of extraversion.

Psychophysiological Links to Extraversion

The literature has clearly demonstrated a relationship between personality, most notably extraversion and athletic ability. This relationship has also been demonstrated not only between elite and non-athletes, but in motor skill and physical ability among the general population. However, the possible physiological mechanisms that create these differences remain unknown. If physiological differences exist, such as differences in strength, this may explain the apparent relationship between extraversion and physical ability.

Extraversion and strength. Tucker (1983b) investigated possible relationships between personality variables (and other psychological variables) and muscular strength. The subjects, 142 undergraduate male students (mean age = 21.76 years), were assessed via the EPI, the Body Cathexis Scale, and the Tennessee Self-Concept Scale. Total strength for each subject was assessed through a one repetition maximum weight lifted during the bench press and squat. These values were then summed together and then normalized against bodyweight to represent relative muscular strength. The mean extraversion and neuroticism levels of the subjects did not differ from the published norms. After analyzing the data, it was determined that relative muscular strength was a significant predictor of extraversion (R^2 = 9.3%, p = 0.003). Also, relative muscular strength was a significant inverse predictor of neuroticism (R^2 = 7.1%, p = 0.03). These findings suggest that as the level of extraversion increases, the relative strength of a subject increases, and the level of neuroticism decreases. This was an expected finding of the study as previous research (Eysenck et al., 1982) predicted that extraverts are more responsive, stable, and impulsive, traits that may physiologically enhance a person's strength. However, relative muscular strength was also a significant predictor of body cathexis (R^2 = 12.3%, $p < 0.0001$) and this variable accounted for the most variance (Tucker, 1983b).

Tucker (1983a) reanalyzed these data *post hoc*. However, this time subjects were differentiated into high and low groups for each assessment variable and then compared the amount of weight lifted between the two groups. Significant differences between the high and low groups were found in all four assessment variables, with extraversion accounting for most of the variance (R^2 = 21.3%, p = 0.0001) and body cathexis accounting for the second most (R^2 = 18.8%, p = 0.0001).

After conducting these two studies, Tucker (1983a, 1983b) concluded that stronger subjects had a greater satisfaction and confidence in their bodies than weaker subjects, and consequently displayed more extraversion and less neuroticism. Tucker contended that a greater self-concept and body cathexis resulted in the subsequent increase in extraversion and muscular strength. This conclusion fundamentally differs with previous research stating that personality variables, including extraversion, remain relatively stable throughout a person's lifetime. This fundamental difference in data analysis and interpretation should be taken into consideration in the work of Tucker. In addition, other studies (Kane, 1964; Kane, 1970) have demonstrated that extraverts inherently tend to be more physically active, thus, it is logical that they may exhibit more muscular strength than introverts due to simply exercising more. However, Tucker (1983a) did demonstrate that there is an apparent, although debatable, relationship between extraversion and strength, which is a measurable physiological outcome.

Another study exploring a possible link between muscular strength and extraversion was conducted by Shiomi (1980). Subjects completed the Maudsley Personality Inventory (MPI), which was the precursor to the EPI, and two groups of 11 introverts ($E < 15$) and 12 extraverts ($E > 15$) were formed. Subjects then performed eight repeated exercise bouts to exhaustion using a bicycle ergometer set at 2.0kps, pedaling at 30km/hr. Subjects were given one minute of rest between each bout and a five minute rest period between the fifth and sixth bout. The length of time the subject could perform the bout was recorded in seconds and listed as a trial. In all 8 trials, extraverts were able to pedal significantly ($p < 0.05$) longer than the introverts. This was especially apparent during trials 1-4 and 6 ($p < 0.01$). Due to these results, Shiomi concluded that extraverts had greater physical strength than introverts. It is important to note that the data were not normalized to subject bodyweight and this was not accounted for in the selection of the subjects. In addition, the repeated bout protocol is generally not considered an appropriate method for assessing a subject's strength as it is not a single maximum bout, or repetition, of work. This protocol may actually shed more light on possible muscular endurance differences between extraverts and introverts. However, the extravert group had a considerably longer first trial length than the introvert group (213.5 sec vs. 87.7 sec), thus, an argument for differences in muscular strength could still be substantiated.

Other possible links. Future research should investigate what physiological mechanisms may be occurring to create this possible psychophysiological link and apparent differences in physical ability between extraverts and introverts. Eysenck et al. (1982) and others have demonstrated that extraverts may exhibit a greater tolerance of pain than introverts, which may allow them to elicit greater effort and/or strength during a physical task. Eysenck et al. (1982) and others also have hypothesized that extraverts and introverts have different cortical arousal and inhibition. This may then result in differences in motoneuronal excitability which could possibly affect motor capabilities and functioning (Stelmack, 1990). A more recently proposed theory is that extraverts are more explosive, powerful, and responsive than introverts, which also matches their personality characteristics, due to these possible differences in motoneuronal excitability (Stelmack, 1990). Another recent theory evolved from this field research has hypothesized that extraverts and introverts recruit motor units at different speeds and/or amplitudes and that introverts may have greater activation of antagonist (non-prime moving) muscles during a physical movement task, which may lead to possible decrements in physical ability (Chany, Parakkat, Yang, Burr, & Marras, 2006; Glasscock, Turville, Joines, & Mirka, 1999; Marras, Davis, Heaney, Maronitis, & Allread, 2000).

Electrophysiological Links to Extraversion

Much of the research investigating the possible mechanistic reasoning to explain the potential physiological link between extraversion and performance is based on the electrophysiological properties of motor function and muscle action. This link has been investigated through the examination of cognitive processing, reaction and movement times, spinoneuronal excitability, and coactivity of antagonist muscle groups.

Extraversion and cognitive processing time differences. Cognitive processing speed is the time needed for the brain to cognitively process the sensory or reactionary information of a stimulus. Once the stimulus is cognitively processed, the brain transmits the required action down to the peripheral nerves and muscles. The speed of cognitive processing can be investigated by examining the amount of electrical activity in specific areas of the brain.

Wilson and Languis (1990) attempted to establish a link between extraversion and cognitive processes by examining brain electrical activity. The researchers used Electroencephalography (EEG), topographic brain mapping technology, to analyze brain processes at 20 different electrode sites during an auditory event-related potential (AERP) task. This task required subjects to listen to different auditory tones and press a counter as quickly as possible when they heard the correct or “target” tone / stimuli. This type of reaction and mental processing causes a waveform to be elicited 250-450 milliseconds post-stimulus, thus, this waveform is called the P300 (or P3). Researchers also recorded reaction time based on the time to button pushing. The researchers used the Myers-Briggs Type Indicator (MBTI) to assess the extraversion levels of 33 subjects (mean age = 16.6 years). Based on the extraversion and introversion scores, the subjects were divided into an extraverted (*E* > 33) group and introverted (*I* > 33) group.

After analyzing the data, the mean amplitude of the P300 waveform was greater (although not significantly) in the introvert group than the extravert group (Wilson, 1990). After subtracting waveforms that were associated with non-target stimuli, statistical differences were found for nine central, parietal, and occipital sites. No significant differences in reaction time were found between extraverts and introverts. Based on these data, the researchers concluded that introverts exhibit a higher cortical arousal level than extraverts, which supports previous hypotheses by H.J. Eysenck (1963). Although Wilson (1990) found no differences in reaction time, the methods used to calculate reaction time were vague and possibly not appropriately applicable. This issue will be further discussed later. Regardless, this study substantiates the theory that there is an electrophysiological link between extraversion and cognitive function.

Stahl and Rammsayer (2004) further investigated the potential link between electrical activity of the brain and extraversion level through a response related task. The apparatus required the 74 female subjects (mean age = 23.8 years) to view a screen, and were instructed to press either *v* or *w* when the corresponding letter appeared on the screen. Subjects performed a practice block of 30 left-hand and 30 right-hand randomized trials to become familiarized with the apparatus, followed by two blocks of recorded experimental trials. The keys used were force sensitive keys attached to strain gauges that digitized and recorded the force applied to the keys, along with time. Reaction Time (RT) was defined as the time from stimulus onset until 50cN of force was reached. Subsequent EEG readings were recorded during the experimental procedure to measure cognitive processing via the amplitude and latency of the P300 and N1 waveforms. Extraversion level was assessed via the Eysenck Personality Questionnaire-Revised (EPQ-R). Extraverts were considered to have extraversion scores of greater than 16 and introverts lower than 16, with scores of 16 being excluded. Subjects were also matched according to their neuroticism scores, to account for possible skewing of the data from extreme neuroticism.

Stahl and Rammsayer (2004) also used EEG to investigate differences in the speed of transmission of sensory input into motor output between introverts and extraverts. This was done by examining the lateralized readiness potentials (LRPs), which represent the readiness potential that occurs several hundred milliseconds prior to voluntary movement. Based off this LRP, the researchers calculated the stimulus-locked LRP (S-LRP) latency, which represents the interval between the stimulus onset and the LRP onset. Thus, the S-LRP latency reflects the duration of brain processes that occur prior to central response activation. The researchers are also able to use the LRP to calculate the LRP response-locked (LRP-R) latency, which represents the interval between the onset of the LRP and the completion of the motor response. Thus, the LRP-R latency reflects the time of central response organization and the actual execution of the motor response.

Although the LRP measures may help distinguish central processing differences between introverts and extraverts, differences in peripheral action are still unknown. To investigate this, Stahl and Rammsayer (2004) also recorded peak response force (RF), time-to-peak (TTP) force, and response-locked electromyogram (EMG-R) recordings. The RF and TTP values were recorded via the force sensitive keys and represent motor response dynamics. The EMG-R latencies and amplitudes were recorded via EMG bipolar sensors placed on the ventral forearm. EMG-R latencies represent the time from onset of muscle activation to the onset of response. If differences in peripheral action are found, these EMG components may represent the underlying mechanistic reasoning.

After analyzing the data, Stahl and Rammsayer (2004) found no significant differences between introverts and extraverts in RT, RF, or TTP. There were also no significant differences in the latencies and amplitudes of the N1 or P300 waveforms. S-LRP latency was significantly ($p < 0.05$) shorter for introverts than for extraverts, but there was no significant difference in S-LRP amplitude. There were also no significant differences in LRP-R latency or amplitude. There were no differences in EMG-R latencies between introverts and extraverts, however, EMG-R amplitude was significantly ($p < 0.05$) larger in introverts than in extraverts. There was also a significant correlation ($r = 0.34$, $p < 0.05$) found between extraversion and S-LRP latency.

Many of the findings of Stahl and Rammsayer (2004) were not anticipated by the researchers. The researchers anticipated a shorter LRP-R latency in extraverts as well as a shorter EMG-R latency in extraverts. These hypotheses were not supported. However, the researchers did hypothesize that no significant differences in N1 or P300 waves would be found and this hypothesis was supported. Stahl and Rammsayer eventually speculated that their hypotheses were not supported due to several reasons. First, the stimulus protocol was not a ‘go/no-go’ protocol meaning the subjects did not have to differentiate if they should press a button or not. Instead, the subject used whatever finger (right or left) was necessary for the stimulus. Secondly, other studies (Doucet &

Stelmack, 1997; Doucet & Stelmack, 2000; Wilson & Languis, 1990) used an auditory stimulus, such as different tone frequencies, that the subjects had to differentiate. Thus, there may be differences in cognitive and motor processing and/or excitation based on the stimulus type. A third reason is the fact that the subjects' fingers were already positioned on the required buttons. This is perhaps the most important reason the anticipated results were not found, because this eliminated the majority of the movement component in the task. The subject's didn't have to move their finger or hand to the button, as it was already positioned in the correct location. If there are potential differences in peripheral motor execution and function, this task design may not properly demonstrate these differences.

Due to the limitations and potential flaws of Stahl and Rammsayer (2004), Stahl and Rammsayer (2008) altered the apparatus design and procedure. The researchers had 56 females (mean age = 22.2 years) view a screen that randomly displayed the letters *v*, *u*, and *w*. The letters *v* and *u* were 'go' indicators and *w* was a 'no-go' indicator. The letters *v* and *u* were randomly assigned to either the left or right hand, but were held constant for each participant. Subjects were instructed to respond as fast as possible, but to not make errors (respond to a 'no-go' stimuli). Five experimental blocks of 12 left hand, 12 right hand, and 12 'no-go' trials were conducted, with a practice block preceding. Extravert and introvert groups were determined in the same manner as Stahl and Rammsayer (2004). The researchers also collected all EEG, EMG, RT, peak RF, and TTP in the same manner as Stahl and Rammsayer (2004). However, researchers also collected stimulus-locked EMG (S-EMG) latency and amplitude, a new EMG data set. S-EMG latency was defined as the temporal interval from stimulus onset to S-EMG onset.

After analyzing the data, Stahl and Rammsayer (2008) found that extraverts responded significantly ($p < 0.05$) more frequently to 'no-go' trials than introverts (1.98% & 0.97%, respectfully). No significant differences were found in RT or TTP, but peak RF was significantly ($p < 0.05$) higher in extraverts (506 cN) than in introverts (320 cN). No significant differences in latency or amplitude were found in the N1 or P300 waveforms. As expected, introverts (365 ms) had a significantly ($p < 0.05$) shorter S-LRP latency than extraverts (389 ms). This indicates that introverts display a faster cognitive stimulus processing than extraverts. In addition, extraverts (87 ms) had a significantly (p < 0.05) shorter LRP-R latency than introverts (106 ms). This suggests that extraverts may have a faster central and/or peripheral motor processing than introverts. No significant differences were found in S-EMG latency or amplitude or R-EMG amplitude between extraverts and introverts. R-EMG latency was consistently shorter in extraverts (30 ms) than introverts (48 ms), however, was not statistically significant ($p < 0.07$).

After performing correlation analyses, Stahl and Rammsayer (2008) determined that S-LRP latency was significantly ($p < 0.05$) positively correlated to extraversion ($r = 0.36$) and that LRP-R latency was significantly ($p < 0.05$) negatively correlated to extraversion ($r = -0.38$). After performing stepwise multiple regression analysis for the prediction of extraversion level, the researchers determined that the combination of LRP-R latency, S-LRP latency, and N1 amplitude accounted for the most variance ($R^2 = 40.3\%$) and was the most significant predictor ($p = 0.013$). Due to these significant correlations, there appears to be a link between S-LRP and LRP-R latencies to extraversion. These tests may assist in identifying mechanistic reasons for physical performance outcomes.

The results of Stahl and Rammsayer (2008) indicate that introverts may be faster at cognitively processing a stimulus, but extraverts may be faster at processing the stimulus into a peripheral motor function. In addition, extraverts produced a greater peak RF than introverts. These findings suggest that the possible differences between extraverts and introverts may be explained by the peripheral nervous system and not centrally. These findings also suggest possible potential differences in power production between extraverts and introverts. With that being said, Stahl and Rammsayer (2008) found no differences in RT or any apparent differences in EMG latencies or amplitudes. Other studies may demonstrate why.

Extraversion and peripheral excitation differences. The literature has demonstrated possible faster cognitive processing and higher cortical excitation in introverts than extraverts during stimulus-response task (Stahl & Rammsayer, 2004; Stahl & Rammsayer, 2008; Wilson, 1990), however much of this research remains inconclusive. If the differences in physiological performance between introverts and extraverts are not due to cognitive processing, it is possible that they are due to differences in peripheral processing. Pivik, Stelmack, and Bylsma (1988) investigated potential differences in peripheral processing by examining the motoneuronal excitability between introverts and extraverts via the spinal monosynaptic H-reflex. The H-reflex is examined by transmitting electrical pulses to the motor nerve of a muscle and recording the resulting EMG wave. The H-reflex recovery is considered to reflect the excitability of alpha motoneurons where the greater the recovery, the higher the motoneuronal excitability. Pivik et al. 1988 assessed 33 women and 31 men (mean age = 21.1 years) via the EPI and the Sensation Seeking Scale (SSS) and created two groups based on the median scores of each assessment for the sample population. During the procedure, subjects laid prone, with their leg supported and flexed at a 35° angle. Pericutaneous muscle stimulation (1.0 ms; 44-115 V pulses) via surface electrodes were administered to the posterior tibial nerve created muscle action potentials. Two trials of increasing stimulus intensity determined threshold and maximum values for direct and reflex responses and H and F reflexes were differentiated. The mean thresholds to elicit direct or reflex responses, as well as the latencies of these responses between the two groups did not differ.

The first method that Pivik et al. (1988) used to investigate reflex responses was by examining reflex recovery after 10 pairs of equal intensity stimuli at stimulus intervals of 40, 50, 100, 200, 300, 400, 600, 800, 1000, and 2000 ms. The reflex amplitude after a stimulus (H1) and the reflex amplitude after the respective paired stimulus (H2), created a ratio of H-reflexes (H2/H1). The ratios were then averaged at each interval for each subject and this represented each subject's H-reflex recovery. The second method of investigating reflex responses was by examining the reflex amplitude recovery after trains of equal intensity stimuli at various rates. The method transmitted 10 consecutive stimuli at 0.03, 0.07, 0.1, and 0.2 pulses per second (pps) and 20 consecutive stimuli at 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, and 10.0 pps, separated by a 1-minute rest period. The downward trend of reflex amplitude that is normally seen is called homosynaptic depression. This homosynaptic depression was quantified into a score for each pulse rate as a proportion of the mean reflex response at the rate of 0.03 pps. Homosynaptic depression is also considered to reflect the excitability of alpha motoneurons; the smaller the depression, the higher the motoneuronal excitability.

Pivik et al. (1988) determined that extraversion was significantly ($p < 0.01$) correlated to Thrill and Adventure Seeking ($r = 0.33$), Disinhibition ($r = 0.49$), and Boredom and Susceptibility ($r = 0.33$) on the SSS Questionnaire, as well as with Total SSS ($r = 0.47$). Since Disinhibition (Dis) was significantly correlated to extraversion, the researchers decided to examine the link between reflex recovery and homosynaptic depression between Dis and Extraversion. After analyzing the data, subjects with high Dis displayed significantly ($p < 0.05$) less reflex recovery than subjects with low Dis. In addition, subjects with high extraversion displayed significantly ($p < 0.03$) less reflex recovery that subjects with low extraversion. No significant interactions were found in the neuroticism or psychoticism groups. When all subjects were pooled together, a homosynaptic depression (i.e., a reduction in reflex amplitude as rate of stimulation increased) was observed.

Pivik et al. (1988) then applied a two-way ANOVA using personality scales and stimulus rates. Introverts displayed significantly smaller depression effects than extraverts ($p < 0.03$). When specific rates were analyzed, extraverts displayed significantly lower amplitude than introverts at rates of 2 to 7 pps. Thus, according to these data, introverts seem to exhibit a greater motoneuronal excitability and extraverts seem to exhibit a reduced motoneuronal excitability. This reduction displayed by extraverts may possibly be due to a longer time course needed for the alpha motoneuronal pool to regain discharge capability after an afferent impulse. Even though exact mechanisms for this phenomenon are unclear, this study does further demonstrate possible physiological links between extraversion and peripheral CNS motor activity. In addition, the functional consequences of a reduced motoneuronal excitability remain unclear. The researchers hypothesize that perhaps individuals with a high extraversion level are not necessarily seeking out stimulation to raise their cortical activity / arousal, but are instead trying to raise their peripheral motoneuronal activity level. This would be through increased physical activity or exercise and would thus, provide insight for why extraverts tend to be more physically active than introverts. The researchers also speculated that extraverts may be more proficient at gross motor activities and introverts may be more proficient at fine motor activities due to these differences.

The study by Stelmack and Pivik (1996) elaborates on the work done by Pivik et al. (1988) by investigating the effects of acute exercise on motoneuronal excitability between introverts and extraverts. Since introverts displayed a greater motoneuronal excitability (via a greater H-reflex recovery and a smaller homosynaptic depression) than extraverts, the researchers wanted to examine if exercise would increase or decrease this excitability. The researchers selected 31 subjects (mean age = 21.3) from a pool of 650 based off of EPQ scores. An extraverted group (mean *E* score = 19.8) of 16 subjects and an introverted group (mean *E* score = 8.1) of 15 subjects were formed. Groups had equal average neuroticism and psychoticism scores. Muscle action potentials were administered to the subjects' posterior tibial nerve via electrodes. Threshold and maximum values for direct responses and reflex responses were determined and F and H reflex were differentiated. Paired stimuli at intervals of 40, 50, 100, 200, 300, 400, 600, 800, 1000, 2000 ms were administered and the ratio of the second stimulus (H2) over the first stimulus (H1) reflected motoneuronal excitability. After this initial reflex recovery data was obtained, subjects completed a brisk 10 minute walk (accurate description of the intensity level of the walk was not stated). Reflex recovery was then assessed in the same manner three more times every 10 minutes.

After analyzing the data, Stelmack and Pivik (1996) determined that introverts once again displayed significantly greater ($p < 0.05$) reflex recovery than extraverts at 600, 1000, and 2000 ms intervals during the pre-exercise stage. The bout of exercise had no significant effect on reflex recovery, however, all significant differences in reflex recovery between introverts and extraverts were eliminated. The researchers concluded that although exercise may not significantly lower the motoneuronal excitability of introverts, exercise did seem to raise the motoneuronal excitability of extraverts to the same level of introverts. This may offer further support to the hypothesis that extraverts seek out physical activity as a way to increase peripheral activation (or arousal) level and not to increase cortical arousal. The researchers also hypothesized that extraverts exhibit a greater dopaminergic activity level than introverts and that this would then explain possible decreased H-reflex recovery.

The review paper by Stelmack and Plouffe (1983) develops several more hypotheses concerning physiological links to extraversion level. This paper develops an argument that physiological differences due to extraversion level are not found in the motor cortex of the brain, but at the peripheral level of sensation and the motor nerve. The authors admit that there may be some kind of relationship between extraversion levels and the N1 and/or P2 waveform amplitude. However, the authors argue that since much of this research investigating cortical arousal via the EEG has shown conflicting or equivocal results, there is a need to explore other methods of investigating physiological differences in extraversion level. The authors review previous studies investigating these differences via Braintstem-Evoked Response's (BERs), which are thought to reflect an individual's electrophysiological response to auditory stimuli. In general, it appears that introverts have a heightened sensitivity to auditory stimuli. For example, introverts tend to find the same noise level or pitch louder and/or stronger than extraverts. Stelmack and Plouffe (1983) also states that many studies have shown differences in pain tolerance between introverts and extraverts. Stelmack and Plouffe (1983) contend that these observations demonstrate differences in peripheral mechanism processes. The authors hypothesize that differences in extraversion level may relate to differences in activity of the sensory nerves.

Stelmack and Plouffe (1983) also review data that suggest that extraverts are more impulsive and commit more false positive errors than introverts. Introverts also tend to be more proficient at fine motor control tasks and extraverts tend to perform better at gross, explosive movements that require short bursts of motor activity. It is due to these findings that the authors further hypothesized that the physiological differences between introverts and extraverts may be found at the motor nerve and not the cortical arousal levels of the brain. Although Stelmack and Plouffe (1983) was a review paper, it successfully directed future research towards the investigation of motor unit recruitment and spinal motoneuronal excitability in relation to quick, powerful movements between introverts and extraverts.

Extraversion and reaction time and movement time differences. Further investigation of the possible differences in responsive, quick movement tasks between introverts and extraverts was continued by Doucet and Stelmack (1997). This study investigated simple reaction time and reaction time after a visual stimulus-response compatibility task. The researchers first assessed the extraversion of 67 right-handed, female subjects via the EPQ. *E* scores of 0-11 formed the introvert group, *E* scores of 13-17 formed the ambivert group, and *E* scores of 18-23 formed the extravert group. The ambivert group was considered the control group for the study as it represented the middle group of values on the extraversion continuum. The reaction time apparatus was a set of three buttons, a home button and right and left target buttons. This study examined reaction time in a new and novel way by differentiating reaction time and movement time. Reaction time (RT) was defined as the time from stimulus onset to the release of the home button. Movement time (MT) was defined as the time from release of the home button to the pressing of the target button. The simple reaction time task required the subject to press a randomized target button after an auditory stimulus. Three blocks of stimuli were used with the target button moved to 7, 15, or 23 cm away from the home button and at an angle of 30°, 65°, and 75° respectively. The stimulus-response compatibility task required subjects to view a monitor and press the correct target button based off of the cue word shown on the screen.

Doucet and Stelmack (1997) determined that during the simple reaction time task, there was no significant effect with extraversion on RT. However, there was a significant effect with extraversion on MT in all three conditions ($F = 4.70$, $p < 0.013$), meaning that introverts displayed significantly slower movements than ambiverts and extraverts. There was no significant difference in MT between ambiverts and extraverts. Another interesting finding was that the difference in MT between introverts and extraverts did not differ across the three conditions. Extraverts moved between 40 and 46 ms faster than introverts during all three distances and angles. When controlling for neuroticism, all three distances (7, 15, and 23 cm) were significantly correlated with extraversion ($r = -0.41$, $p = 0.001$; $r = -0.32$, $p = 0.01$; $r = -0.31$, $p = 0.01$ respectively).

When analyzing the stimulus-response compatibility data, Doucet and Stelmack (1997) determined that extraverts displayed a significantly faster RT in the incompatible-congruent condition, but not in the other three conditions. Also, there was no significant correlation between RT and MT, unlike the simple reaction task. The researchers hypothesized that the effects of extraversion on reaction tasks are not as evident when the cognitive demands are high. However, extraverts still displayed significantly ($p < 0.02$) faster MT time than both introverts and ambiverts in all four conditions. Extraverts moved between 38 and 42 seconds faster than introverts, demonstrating that although an increase in the cognitive demands may affect initial RT between introverts and extraverts, the differences in the movement component of the reaction still remain unchanged. In addition, when once again controlling for neuroticism, the correlations were significant ($p < 0.01$) for all four conditions, ranging from $r = -0.30$ to $r = -0.40$.

The findings of Doucet and Stelmack (1997) are extremely important as they demonstrate that the difference in speed of movement is originated at the onset of the MT component and not the RT component. These findings also further exhibit that the physiological differences between extraverts and introverts are occurring at the peripheral motor nerve. Doucet and Stelmack (1997) also go on to speculate that extraverts and introverts may have the same average velocities (or peak velocities) of movement, but extraverts are able to accelerate faster than introverts. If this theory is correct, there may be differences found in velocity and force production (force vs. time curve), which would result in possible differences in power production.

Doucet and Stelmack (2000) furthered the investigation of Doucet and Stelmack (1997) *post hoc* by examining the possible differences in the N1 and P300 EEG waveforms. The stimulus response apparatus and procedures, as well as all the data is from Doucet and Stelmack (1997). Doucet and Stelmack (2000) determined that there were no significant group differences in P300 amplitude or latency or N1 latency between extraverts and introverts. However, introverts displayed a significantly ($p < 0.005$) higher N1 amplitude than extraverts across all three conditions. The researchers hypothesized that this could be due to differences in sensory reactivity from the auditory stimuli (i.e., the loudness of the beep). After controlling for neuroticism, N1 amplitude was also significantly ($p < 0.01$) negatively correlated to extraversion in all the three conditions, ranging from $r = -0.39$ to $r = -0.44$.

After analyzing the data from the stimulus-response compatibility task, no differences in P300 amplitude or latency were found between introverts and extraverts in any of the conditions. Although there appeared to be differences in P300 latency and amplitude between the conditions themselves, no significant differences between the groups were exhibited. N1 waveform data was not collected during the stimulus-response compatibility task. After controlling for neuroticism, P300 latency was significantly ($p < 0.05$) correlated to extraversion in the congruent-incompatible ($r = 0.29$) and incongruent-compatible ($r = 0.26$) conditions. The researchers hypothesized that extraverts may require additional processing time when the task stimulus is in conflict with the response selection.

The findings of Doucet and Stelmack (2000) are important as they demonstrate that there are no differences in cognitive processing speeds between introverts and extraverts when the stimulus evaluation demands are simple and minimal (i.e., go/no-go tasks). There may be differences in cognitive processing speed when the stimulus evaluation demands are higher and more complex, but no definitive data was found. Ultimately, these findings further substantiate the suggestion that physiological differences in reaction time between introverts and extraverts occurs at the peripheral motor nerve level, and not at the central cognitive processing level. As a result, functional performance may be influenced due to the necessary level of peripheral nerve involvement in such tasks. Future studies should further investigate possible gross and functional movement differences between extraverts and introverts.

Extraversion and functional performance. Now that electrophysiological differences at the level of the peripheral nerve between introverts and extraverts have been established, the overall functionality of these differences remains unclear. Specifically, if introverts display a greater motoneuronal excitability and extraverts display a faster movement time, the ultimate functional outcomes that manifest from these differences remain unclear. If these physiological mechanisms possibly change the functionality of movement patterns or the loading of joint, this could result in significant differences in physical ability between extraverts and introverts.

Extraversion and coactivity of agonist and antagonist muscle groups. When investigating possible differences in functional performance between personality groups, the literature has primarily examined agonist and antagonist muscle group activity. The agonist muscle groups are considered to be the *prime movers* of a movement and the antagonist muscle groups are considered to be the muscles that perform the opposite of the movement, or in some cases, oppose the movement. During elbow flexion, the biceps muscle is the agonist muscle during elbow flexion and the triceps muscle is the antagonist muscle. If the activity level of either one of these muscle groups is altered, the resulting movement may be compromised. For example, if the activity level of the antagonist muscle group opposing a particular movement is higher in subject A than in subject B, the resulting movement of subject A may not be as forceful, powerful, or precise. The loading of a joint, such as adding weight, can also be affected by greater antagonist muscle group activation. If the antagonist muscle group is highly activated (or if the activity of the agonist group is not adequate), a greater biomechanical load will be placed onto the joint. Thus, improper activity of either muscle group may also increase the risk of injury because the movement is not being produced optimally or the joint is not being properly loaded.

Glasscock et al. (1999) investigated possible differences in muscle activation (or coactivation) during elbow flexion between Type A and Type B personality groups. The researchers hypothesized that Type A individuals would exhibit a greater antagonist muscle activity than Type B individuals. The researchers assessed the personality profiles of 11 men and 15 women ages 21 to 51 ($\bar{x}$ = 27.8) years via the Jenkins Activity Survey. Subjects were divided into three groups based on their scores: Type B (0-33), Type AB (34-66), and Type A (67-100). This resulted in ten Type B subjects, six Type AB subjects, and ten Type A subjects, however, the Type AB subjects were excluded from the data analysis. The loading of the elbow joint was assessed through the use of a dynamometer. The subjects performed isometric trials of 20%, 40%, 60%, and 80% of their individual maximum isometric flexion torque, isokinetic trials of 20% and 40% of their individual maximum isometric flexion torque, and isoacceleration trials of 20% and 40% of their individual maximum isometric flexion torque. Percentage of deviation from the target torque was also calculated. Elbow flexion velocity (0°/s and 50°/s) and elbow flexion acceleration (0°/s^2 and 50°/s^2) were also recorded. Subjects performed two repetitions of each task and the task order was randomized. The isometric tasks were performed at 90° of elbow flexion and the dynamic tasks were performed through a 40° arc of motion, but the data was only analyzed during the 89° to 91° range of motion.

Glasscock et al. (1999) examined the muscle activity of the subjects by recording EMG from seven muscles: biceps brachii long head (BLONG), biceps brachii short head (BSHORT), triceps brachii long head (TLONG), triceps brachii lateral head (TLAT), triceps brachii medial head (TMED), brachialis (BRA), and brachioradialis (BRAD). EMG amplitudes of each muscle were integrated forming integrated EMG (IEMG) data. The IEMG values were then normalized (NIEMG) against the maximum voluntary contraction (MVC) IEMG value obtained for each muscle at 90° flexion or extension. These NIEMG values display relative activation levels of each collected muscle. The NIEMG values were then multiplied by the estimated physiological cross-sectional area (PCSA) and muscle activity (MA) of each muscle to calculate the torque generated by each individual muscle. The ratio of the sum of the extensor forces (antagonists) over the sum of the flexor forces (agonists) was then calculated to form a measure of relative antagonism (ScRATIO).

After analyzing the data through several ANOVA calculations, Glasscock et al. (1999) determined that there was no significant effect between personality and isometric flexor muscle (agonist) torque. However, there was a significant effect between personality and extensor muscle (antagonist) torque as Type A subjects had a significantly higher extensor muscle activity that Type B subjects ($p < 0.05$). In addition, 98.8% of the individual ScRATIO data points for Type A subjects were greater than the median ScRATIO value of Type B subjects. This demonstrates greater antagonist activation, and an overall different muscle activation pattern, in Type A subjects during elbow loading. The mechanism (peripheral or central) of this apparent muscle coactivity remains unclear. The researchers previously hypothesized that this coactivation occurs to increase the accuracy of output. However, the percentage of deviation from the submaximal target torque was not different between Type A and Type B subjects (4.0% and 4.3%, respectively), demonstrating no difference in the accuracy of output.

After this data analysis, Glasscock et al. (1999) hypothesized that this observed increased coactivation of antagonist muscles pattern may in fact actually result in an increased biomechanical loading of the joint tissues (i.e., muscle, tendon, ligament) in Type A individuals. This increased coactivation may also inhibit joint range of motion in Type A individuals. Both of these factors may contribute to an increased likelihood (or risk) of injury in Type A individuals. Thus, future research should investigate muscle coactivation and loading differences, as well as subsequent injury rates, between personality groups (most notably in extraverts and introverts).

Marras et al. (2000) furthered this line of research by investigating possible loading differences of the lumbar spine between personality groups. The researchers instructed 25 subjects (15 male and 10 female) to perform five controlled lifts during stressed and unstressed conditions. The subjects were required to lift a 13.6 kg mass at precise trunk extension velocities (within ±1.5%) of: 15°/s, 30°/s, 45°/s. The researchers assessed the anxiety level of the subjects, via the STAI, before the unstressed condition, after the unstressed condition (in between conditions), and after the stressed condition. The unstressed condition consisted of the researchers providing positive language and actions to encourage the subjects while moving the weight in the desired direction. The stressed condition consisted of the researchers providing negative and unsupportive language and actions to discourage the subjects while moving the weight in the desired direction.

Marras et al. (2000) recorded the trunk kinematics data via a Lumbar Motion Monitor and collected EMG data via bipolar surface electrodes. EMG data were collected from the right and left muscle pairs of the latissimus dorsi, erector spinae, external and internal obliques, and rectus abdominis. EMG data were then normalized to the MVC in each of the six directions that the subject had to lift the weight. These EMG signals assisted in creating the three-dimensional model that predicted spinal load. A forceplate and electrogoniometers were used to measure the three-dimensional external movements. Heart rate monitors and an automatic blood pressure monitor were used to collect stress-related data. The personality profiles of the subjects were assessed through the MBTI.

After data analysis was complete, Marras et al. (2000) found several significant interactions between personality and spinal loading under stressed conditions. Specifically, subjects that displayed introversion personality preferences demonstrated a significant ($p < 0.05$) increase in lateral shear force (27.2%) and compression force (13.7%). This increase in lateral shear force was exhibited through a significant

($p < 0.05$) increase in trunk acceleration (10.8%) and a significant ($p<0.05$) increase in external oblique muscle activity (18.7%). During unstressed conditions, there were no significant differences in spinal loading, thus, personality types appear to functionally respond to stress in different physiological ways. The researchers hypothesized that introverts increased their coactivation as a method of controlling the new, stressful situation. However, this increase in coactivation results in a higher spinal loading and subsequent injury risk.

Chany et al. (2006) continued this line of research in the literature by investigating if these differences in spinal loading between personality groups are evident in both experienced and inexperienced lifters, and if these differences are evident over a long duration of repeated lifts. The researchers recruited 24 subjects (3 females and 21 males) ranging in age from 19 to 33 years, to perform repetitive loading tasks for eight hours, split into four two hour blocks of time, on six different days. The subjects were differentiated by their manual material handler (MMH) experience level into a novice (no MMH experience) group of 12 subjects and an experienced (at least 1 year of MMH experience) group of 12 subjects. The subjects were required to lift loads of 8, 36, and 85 Nm at frequencies of 2, 4, 6, 8, 10, 12 lifts/min (lpm). The subjects lifted at a different particular frequency during each different day. The personality profiles of the subjects were assessed via the MBTI and then divided into two categories: Sensor/Intuitor (SN), and Perceiver/Judger (PJ). Not a large enough of sample of subjects that matched the other personality profiles was collected to exhibit a large enough statistical power, thus, these groups were excluded (i.e., Introvert/Extravert and Feeler/Thinker).

Chany et al. (2006) collected EMG data via bipolar surface electrodes over 10 different trunk muscles. The EMG data was then normalized to MVC values in the direction of the lifts. This EMG data assisted the Lumbar Motion Monitor in developing the three-dimensional biomechanical model used to measure trunk kinematics and assess spinal load. Goniometers and force plates were used to assess pelvic tilt and rotation.

Chany et al. (2006) calculated that intuitors displayed a significantly ($p = 0.0206$) higher (12%) anterior posterior shear than sensors. The researchers also calculated that perceivers had a significantly ($p < 0.0001$) higher (16%) spinal compression, and a significantly ($p < 0.0001$) higher (12%) lateral shear than judgers. These findings demonstrate a difference in compressive and shear spinal loading between personality groups. The researchers concluded that personality characteristics influenced the motor controls strategies used amongst the subjects during lifting tasks. The researchers hypothesized that the stress of the repetitive lifting tasks was perceived differently among the personality groups and that this increased stress manifested in some groups (i.e., perceivers and intuitors) as an increase in muscle coactivity. This increased muscle coactivity subsequently led to high spinal loads. This difference in perceived stress of the lifting task was concluded by Chany et al. (2006) to be a personality-job mismatch. The researchers also speculated that this apparent personality-job mismatch may hinder the required motor skill learning of the job or task.

These observed physiological differences in muscle coactivation between personality types are very important as these studies (Glasscock et al., 1999; Marras et al., 2000; Chany et al. 2006) were the first to show differences between personality types in a functional movement capacity. However, future research should investigate if these differences are observed specifically between the introvert and extravert personality groups, as determined through the EPI. In addition, future research should investigate if these differences in muscle activation result in differences in a functional physiological performance outcome (i.e., power production or strength). This increased coactivation displayed in introverts (and other personality groups) may not only result in an increase probability of injury, but may result in performance decrements as well. If improper agonist or antagonist muscle activity is occurring, power production and/or strength may be impaired due to a decrease in the efficiency of muscle activity. For example, if the hamstring muscles (antagonist) are coactivated with the quadriceps (agonist) muscles during a leg extension, a decrease in force production is likely due to the two muscle groups ‘opposing’ each other. Also, as hypothesized by Chany et al. (2006), some personality groups may display an inhibited motor skill development due to a personality-job mismatch. This same mismatch may also translate into the athletic population and may subsequently explain previous differences in sport participation and skill level between personality groups (Eagleton et al., 2007).

Conclusion

The literature has demonstrated that many physiological performance differences exist between personality groups, and specifically between introverts and extraverts. These differences are exhibited in physical activity level (Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965), sport performance (Briggs et al., 1979; Eagleton et al., 2007; Morgan & Johnson, 1978; Morgan et al. 1988), and possibly even strength (Shiomi, 1980; Tucker, 1983a; Tucker, 1983b). However, the actual mechanistic reasoning behind these observed physiological differences is relatively unknown. Several hypotheses concerning possible electrophysiological links have been formulated, but many have not been properly explored or have resulted in equivocal results. For example, investigations of possible differences in cognitive processing time between introverts and extraverts have exhibited both significant and non-significant results (Stahl & Rammsayer 2004; Stahl & Rammsayer 2008; Wilson, 1990).

However, investigations of the peripheral excitation differences between introverts and extraverts have demonstrated significant results (Pivik et al., 1988; Stelmack & Pivik, 1996; Stelmack & Plouffe, 1983). Extraverts have demonstrated a depressed motoneuronal excitability, thus creating the hypothesis that extraverts seek out gross motor activity to raise their peripheral excitation level. Investigations of the peripheral movement time and reaction time differences between introverts and extraverts have also demonstrated significant results (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000). While no conclusive functional or mechanistic differences have been demonstrated, extraverts routinely exhibited a faster movement time than introverts in simple go/no-go tasks. These findings have led researchers to speculate that the previously observed performance differences stem from extraverts displaying the ability to move more quickly and explosively, and may subsequently be able to generate a greater power output than introverts (Doucet & Stelmack, 2000). Investigations of muscle coactivity during movement tasks have also demonstrated differences between personality groups (Chany et al,. 2006; Glasscock et al., 1999; Marras et al., 2000). Due to these observations, it is reasonable to speculate that possible differences in muscle activity (i.e., motor unit recruitment and/or amplitude) in the agonist and/or antagonist muscle groups may hinder the motor skill level of introverts. These differences in muscle activity level may also ultimately manifest themselves in differences in power production during a dynamic movement and overall athletic ability.

These demonstrated differences in muscle activity and movement time between introverts and extraverts has left a gap in the literature. In order to fill this gap, future research should investigate possible differences in power production during a dynamic task between extraverts and introverts. In addition, future research should examine possible relationships of these performance measurements to functional movement outcomes and the underlying mechanistic reasoning (i.e., agonist/antagonist muscle activity).

CHAPTER III: METHODS

Introduction

The primary purpose of this study was to investigate the potential relationship between counter movement jump (CMJ) performance (i.e., peak height, peak power, peak force, & peak velocity) and extraversion level. The secondary purpose was to examine electrophysiological mechanisms (i.e., muscle activity level) that may further describe the potential relationship between CMJ performance and personality. The muscle activity level was examined through the use of surface electromyography (EMG). This study was the first of its kind to investigate a possible relationship between power production and extraversion level during a gross movement task. This study contributes to the literature by investigating possible psychophysiological links between personality and physiological performance. The methodology that was used to facilitate the purposes of this study, including the participants, psychological assessments, instrumentation, equipment, protocols, and data processing, will be described in the following sections. This study was approved by the Institutional Review Board (IRB) of the University of Wisconsin – Milwaukee (UW-M) on April 17, 2012 (IRB Protocol Number = 12.293).

Participants

All participants were recruited from the UW-M campus and the surrounding Milwaukee, WI community. This study utilized flyers (Appendix A) and word of mouth, and also attempted to recruit students from several undergraduate classes at UW-M. Participants received no monetary compensation for participation.

Criteria for inclusion. Before any data were collected or any explanation of the study commenced, the participant completed the Criteria for Inclusion Questionnaire

(Appendix B). The participant was excluded if they were taking prescribed medication for a symptomatic illness, had an injury, surgery, or bone abnormalities on their knees, hips, or ankles in the last year, had a heart condition or any chest pain, were pregnant, suffered from dizziness, had hearing impairments (due to the stimulus being an auditory tone), or did not meet any of the following inclusion criteria for gender, age, and/or physical activity level.

Gender. Differences in extraversion and neuroticism levels between genders have been reported in the literature by Lynn and Martin (1997). In addition, much of the previous literature has only examined potential physiological differences in females (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000; Stahl & Rammsayer, 2004; Stahl & Rammsayer, 2008). Due to these factors and to remain in accordance with the previous literature, only females were examined in the current study.

Age. Level of extraversion has also been shown to decrease in individuals during their lifespan (H.J. Eysenck & Eysenck, 1968). This decline has been attributed to the decrease in the excitation and/or inhibition capabilities of the ascending reticular activation system (ARAS) due to the aging of the central nervous system (H.J. Eysenck, 1963). This study controlled for this decline by only recruiting participants within 18-29 years of age, as extraversion level in this age group is considered to be stable.

Activity level. All participants must have reported to be engaged in regular exercise based on the recommendations of the American College of Sports Medicine (ACSM) for a minimum of six months (i.e., 150 minutes of moderate intensity physical activity per week or 75 minutes of vigorous intensity physical activity per week; Garber et al., 2011). Minimum physical activity level and participation in an organized, competitive sport of an elite level (i.e., member of a National Collegiate Athletic Association Division I sports team) was an exclusion criteria as this study examined possible relationships between personality and physiological mechanisms amongst participants with similar exercise habits and skill ability. It is also known that most elite level athletes are considered to be more extraverted than their non-elite counterparts (Eagleton, McKelvie, & deMan, 2007). The factors of physical activity level and physical ability level created the need to control for physical activity and physical ability level in order to recruit a sample population with a wide range of extraversion level, as well as similar physical ability.

Study Design

This study consisted of three phases. Phase 1 consisted of personality measurement, Phase 2 consisted of anthropometric measurements and Phase 3 consisted of the CMJ measurements. All three phases took place in the Human Performance and Sport Physiology (HPSP) Laboratory, located in the Pavilion, Room 365 (3409 N. Downer Ave, Milwaukee, WI 53211), on the campus of UW-M. The participant must have met all previously described inclusion criteria before being advanced to Phase 1 of this study (Appendix B). To ensure accurate measurements and maximal performance level, the participants were instructed to refrain from smoking (or any other tobacco product) and caffeine intake, as well as any heavy resistance training, the 4 and 48 hours preceding Phases 1-3, respectively. To ensure consistent measurements, all measurements were conducted by the primary student investigator (David Cornell). Any other supporting assistance consisted of aiding with EMG equipment and/or supplies.

Phase 1. The participant first read and gave Informed Consent (Appendix C). Once Informed Consent was given, the Eysenck Personality Inventory (EPI) Form B was administered (*The Manual of the Eysenck Personality Inventory*, 1968). This 57-question survey assesses the extraversion and neuroticism levels of an individual (Appendix D). The EPI is considered a valid and reliable personality assessment tool (H.J. Eysenck & Eysenck, 1968). Based on the neuroticism scores on the EPI, two groups were created: participating and non-participating. The individuals in the non-participating group were not advanced to Phase 2 of this study. The EPI data from the participants that were not advanced to Phase 2 were retained, but not used in the data analysis of this study. This study recruited a total of 30 participants, with 25 participants advancing to Phase 2.

Extraversion. This study hoped to create a wide range of extraversion level amongst the sample population based upon the EPI. The published normative mean extraversion score by H.J. Eysenck and Eysenck (1968) is 15.2 with a standard deviation of 3.5. Thus, this study attempted to create a sample that coincided with these values.

Neuroticism. Participants had to score within one standard deviation (σ = 4.8) of the published normative value for neuroticism for American students ($\bar{x}$ = 11.4) on the EPI Form B (H.J. Eysenck & Eysenck, 1968). This created a window of acceptable neuroticism scores ranging from 6-17. Participants with neuroticism scores outside the standard deviation range were placed into the non-participating group and were not advance to Phase 2 of the study.

This measure was incorporated due to the fact that an individual's performance level seems to decrease as their neuroticism level increases (Eysenck, Nias, & Cox, 1982). In addition, neuroticism level has been suggested to change throughout an individual's lifespan and also is dependent on the stress and/or anxiety level of the individual (Eysenck et al., 1982). Due to this, the level of neuroticism needed to be controlled amongst the recruited participants.

Exercise History Questionnaire. The participant also completed an Exercise History Questionnaire (Appendix E). This questionnaire assessed the amount and types of physical activity that the participant regularly engages in during her normal daily activities, as well as during her typical exercise routines. This questionnaire also assessed the type of competitive sports and positions that the participant may have previously participated in. The intent of this questionnaire was to try to control for any training effect that may have skewed the resulting data. However, this questionnaire was not ultimately utilized in the data analysis process.

Phase 2. Once placed into the participating group, the testing protocol and the CMJ were explained to the participant and any questions the participant had were answered. The participant was asked to practice the CMJ several times to become familiarized with the protocol. The physiological measurements of height, weight, thigh circumference, limb length, thigh skin fold, and total thigh muscle cross-sectional area (CSA) were also taken at this time.

***Counter movement jump instructions*.** The CMJ was performed in accordance with guidelines established by Myotest Inc (Appendix F). In brief, the participant started with her hands on their hips. At the sound of the second beep (stimulus) the participant performed a squatting motion (bending their knees) and then immediately propelled herself upwards, jumping as high and as fast as possible. The depth of the counter movement was not controlled and the participant was simply instructed to squat down to whatever level she felt would result in the highest CMJ. The participant was also instructed to land as *softly* as possible. The data for the each jump (trial) was validated that it was measured and recorded successfully before beginning the next trial.

Height and weight. Height and body weight were measured with a medical balance-beam scale with a stadiometer (Detecto, Webb City, MO). Height was recorded to the nearest centimeter (cm) and weight to the nearest 0.1 kilogram (kg). Based on these measurements, the body mass index (BMI) score of the participant was calculated by dividing weight (kg) by height squared (m^2), and recorded to the nearest tenth decimal place.

Thigh circumference. Thigh circumference of each participant was measured according to the procedures described in the 7^{th} Edition of the ACSM's Guidelines for Exercise Testing and Prescription (American College of Sports Medicine, 2006). While the participant was standing with one foot on a bench so that her knee is flexed at a 90º angle, the circumference of the thigh was measured at the midpoint between the inguinal crease and the proximal border of the patella of the participant. All measurements were taken through the use of a Gulick, a cloth tape measure with a spring-loaded handle, (Creative Health Products, Plymouth, MI) to ensure accuracy and consistency of measurements. All measurements were recorded to the nearest centimeter (cm).

Limb length. The length of both lower limbs of the participants was measured following the previous protocol used by Plisky (2006). In brief, while the participant was laying supine, a mark was placed on the most inferior portion of the anterior superior iliac spine (ASIS) and the most distal portion of the lateral malleolus. The limb length from the marks on the ASIS to the marks on the lateral malleolus of the participant was then measured. All measurements were taken with the equipment as previously described above. All measurements were recorded to the nearest centimeter (cm).

Thigh skin fold. The thigh skin folds of both the right and left legs of each participant were measured according to the procedures described in the 7th Edition of the ACSM's Guidelines for Exercise Testing and Prescription (American College of Sports Medicine, 2006). In brief, a vertical fold measurement was taken on the anterior midline of the thigh, midway between the proximal border of the patella and the inguinal crease of the participant. All skinfold measurements were taken with a Lange skinfold caliper (Beta Technology, Santa Cruz, CA). All skinfold measurements were recorded to the nearest millimeter (mm).

Thigh muscle cross-sectional area. Total thigh muscle CSA of each leg was calculated using the previously measured thigh circumference and thigh skinfold measurements. These measurements were inserted into the following validated formula: CSA = (4.68 × mid-thigh circumference in cm) – (2.09 × anterior thigh skinfold in mm) – 80.99 (Housh, Housh, Weir, Weir, Johnson, & Stout, 1995). Total thigh muscle CSA was recorded to the nearest 0.1 square centimeters (cm^2).

Phase 3. The participant first performed a brief, 5-minute warm-up on a Monark Ergomedic 828E bicycle ergometer (Monark Exercise, Vansbro, Sweden) with a light, self-selected, resistance level. This measure was taken to ensure proper muscle fiber length and elasticity of the participant. Once the participant was properly warmed up, the following measurements were taken.

Hip range of motion. The hip joint range of motion of each leg of the participant was measured through the use of a Gollehon Model 01135 extendable goniometer

(Lafayette Instrument Company Inc., Lafayette, IN). Goniometric alignment protocol established by Higgins (2011) was utilized. In brief, the participant performed an active straight leg raise while lying supine. The range of motion of her hip joint was measured as the deviation from the neutral zero position, with the thigh and trunk in the horizontal plane. The moveable arm of the goniometer was aligned with the lateral midline of the thigh, the stationary arm was aligned with the midline of the pelvis, and the axis was centered over the greater trochanter. The range of motion of the hip joint was recorded to the nearest degree (°).

Hip flexibility. Hip flexibility of each participant was measured by utilizing an Acuflex I modified sit and reach measurement device (Novel Products Inc., Rockton, IL). The standardized modified sit and reach protocol described by Hoeger (2007) in *The Assessment of Muscular Flexibility* was utilized. In brief, the participant sat with her back against the wall and legs fully extended touching the device (with shoes off). The participant then placed her dominant hand over the other and reached out with her arms fully extended, without letting her back or head come off the wall. The slider was then moved forward until it was touching the participant’s fingertips and the starting position was recorded. The participant then slowly and controllably reached forward three times, reaching out as far as she could, while her knees were kept flat against the floor. All sit and reach test scores were measured to the nearest cm and recorded.

Surface Electromyography. Bipolar surface electrodes (Vermed MeshTrode A10040-60, 7/8” rectangular solid gel, silver-chloride snap connector) were placed along the biceps femoris (BF), semitendinosus (ST), vastus lateralis (VL), rectus femoris (RF), and vastus medialis (VM) muscles (Vermed Inc., Bellows Falls, VT). Electrodes were placed in accordance with the European Recommendations for Surface Electromyography SENIAM Project (Hermens et al., 1999). Interelectrode impedance was minimized by shaving, gently rubbing the area with sterile gauze, and wiping the area clean with an alcohol swab. EMG measures were recorded with the Noraxon Telemyo 2400T G2 system (bandwidth of 10-500 Hz) at a sample rate of 1500Hz (Noraxon U.S.A. Inc., Scottsdale, AZ).

Once the EMG unit was attached and connected to the electrode leads, two maximum voluntary contraction (MVC) tasks were conducted: one MVC for the quadriceps and one MVC for the hamstrings. These MVC tasks were used to normalize individual EMG signals to allow for comparisons across all participants. All MVC EMG data were collected while the participant sat in a comfortable chair with her leg fixed at 90º of knee flexion. The MVC for all portions of the quadriceps and hamstrings was tested through manual muscle testing by having the participant undergo knee extension (kicking leg out) and flexion (pulling leg back), respectfully.

All EMG signals were stored on a laptop for subsequent analysis using MyoResearch XP software. Prior to data analysis, the EMG signals were rectified for a time period corresponding to the propulsion phase of the CMJ. The propulsion phase was identified by using an auditory tone to initiate the CMJ sequence and a subsequent marker placed in the EMG data. The propulsion phase was also identified through the use of an electrical goniometer that measured the angle of right knee flexion and will be described in further detail later. The peak EMG amplitudes were identified from the propulsion phase from the highest CMJ trial for each muscle. Peak EMG amplitude values for each muscle during the highest CMJ trial were then normalized to the peak values for each muscle obtained from the normalization task. Subsequently, the peak values from the VL, RF, and VM were summed to create a peak value for the quadricep muscle group, and the peak values from the BF and ST were summed to create a peak value for the hamstring muscle group.

Maximum and Minimum Knee Flexion. Maximum and minimum right knee flexion during the CMJ trial was measured using a Noraxon 2D Inline Electrical Goniometer Sensor (Noraxon U.S.A. Inc., Scottsdale, AZ). The data from this goniometer were simultaneously measured and collected with the EMG data by the Noraxon Telemyo 2400T G2 system and MyoResearch XP software. All electrical goniometer measurements were recorded in the nearest tenth of a degree. The goniometer sensor was placed laterally across the knee joint, in line with the lateral malleolus and mid-thigh. The x-axis sensor was placed below the knee joint and the y-axis sensor was place above the knee joint. The start of the propulsion phase was determined at the point of maximum knee flexion (i.e., the lowest part of the squatting motion) after the auditory stimulus. The end of the propulsion phase was determined at the point of minimum knee flexion (i.e., the full extension of the knee) after the auditory stimulus.

Myotest Sport unit. Lastly, the participant was fitted with the Myotest Sport unit and belt and the CMJ instructions were once again explained to the participant. The belt was fitted around the waist of the participant with the Myotest Sport unit positioned over her left hip. The participant’s height (cm) and body weight (kg) were entered into the Myotest Sport unit. All peak height, peak power, peak force, and peak velocity values of each CMJ were measured via the Myotest Sport unit (Myotest Inc., Durango, CO). The reliability and validity of the Myotest unit have been verified in the work of Nuzzo, Anning, and Scharfenberg (2011) and Casartelli, Muller, and Maffiuletti (2010). The Myotest Sport unit automatically normalized all CMJ power and force values to the participant's bodyweight. The participant then performed several practice CMJ trials to ensure proper technique and that the Myotest Sport unit and EMG equipment properly record the jump and resulting muscle activity.

Counter movement jump trials. The participant performed three successful CMJ trials and the peak height, peak power, peak force, and peak velocity values, as measured by the Myotest unit, were recorded between each successful trial. The peak height, peak power, peak force, and peak velocity of the highest CMJ trial were used for all data analysis in this study. A CMJ trial was considered unsuccessful if: the participant started her movement before the proper stimulus (i.e., false start), the participant removed her hands from her hips, the Myotest Sport unit could not properly assess the trial, or the EMG data were not properly recorded. All data from the unsuccessful CMJ trials were discarded. To ensure a high motivation level of the participants, positive verbal motivation and feedback was administered to the participant before and after each CMJ trial.

Statistical Analysis

All statistical analyses were calculated using the IBM SPSS Statistics 19 software (IBM Corporation, Armonk, New York). Bivariate Pearson correlations (n = 8) were used to examine the relationships between personality (i.e., extraversion & neuroticism) and the CMJ performance measures (i.e., peak height, peak power output, peak force output, & peak velocity) during the highest CMJ trial. Bivariate Pearson correlations

(n = 8) were also used to examine the relationships between personality (i.e., extraversion & neuroticism) and the EMG data of the quadricep and hamstring muscle groups during the highest CMJ trial. Follow-up analyses included bivariate Pearson correlations (n = 10) between all other collected physiological variables and the CMJ performance measures during the highest CMJ trial, as well as bivariate Pearson correlations between all other collected physiological variables and the EMG data of the quadricep and hamstring muscle groups during the highest CMJ trial. An alpha of $p < 0.05$ was considered statistically significant for all comparisons.

CHAPTER IV: RESULTS

Introduction

The primary purpose of this study was to investigate the potential relationship in counter movement jump (CMJ) performance (i.e., peak height, peak power, peak force, & peak velocity) and extraversion level. The secondary purpose was to examine electrophysiological mechanisms (i.e., muscle activity level) to identify possible contributions that muscle activation may play in relation to CMJ performance. It was hypothesized that peak height, peak power, peak force, and peak velocity output of the highest CMJ trial would be positively correlated to extraversion level. It was also hypothesized that extraversion level would be positively correlated to greater muscle activation in the agonist muscles (quadriceps) and that extraversion level would be negatively correlated to greater muscle activation in the antagonist muscles (hamstrings) during the propulsion phase of the highest CMJ trial.

Outcomes of interest. The primary outcomes of interest were the relationships between measures of personality (i.e., extraversion & neuroticism) and peak height, peak power, peak force, and peak velocity of the CMJ. The secondary outcomes of interest were the relationships between extraversion and muscle activity of the quadriceps and hamstrings during the highest CMJ trial, and the relationships between neuroticism and muscle activity of the quadriceps and hamstrings during the highest CMJ trial. Tertiary outcomes of interest of this study included other physiological characteristics and their relationships to CMJ measures, such as hip range of motion (ROM), and minimum and maximum knee flexion during the highest CMJ trial.

Participants

Participant recruitment. Figure 2 portrays a recruitment flow diagram of participants of this study. A total of 30 participants were recruited and underwent the testing protocol for Phase 1 of this study. Five participants were not advanced to Phase 2 of this study due to a neuroticism score outside of the range of 6-17. All 25 participants that advanced through to Phase 2 also advanced to Phase 3 of the study, and subsequently completed all three phases of the study. All participants were recruited from the University of Wisconsin – Milwaukee (UW-M) campus and surrounding greater Milwaukee area.

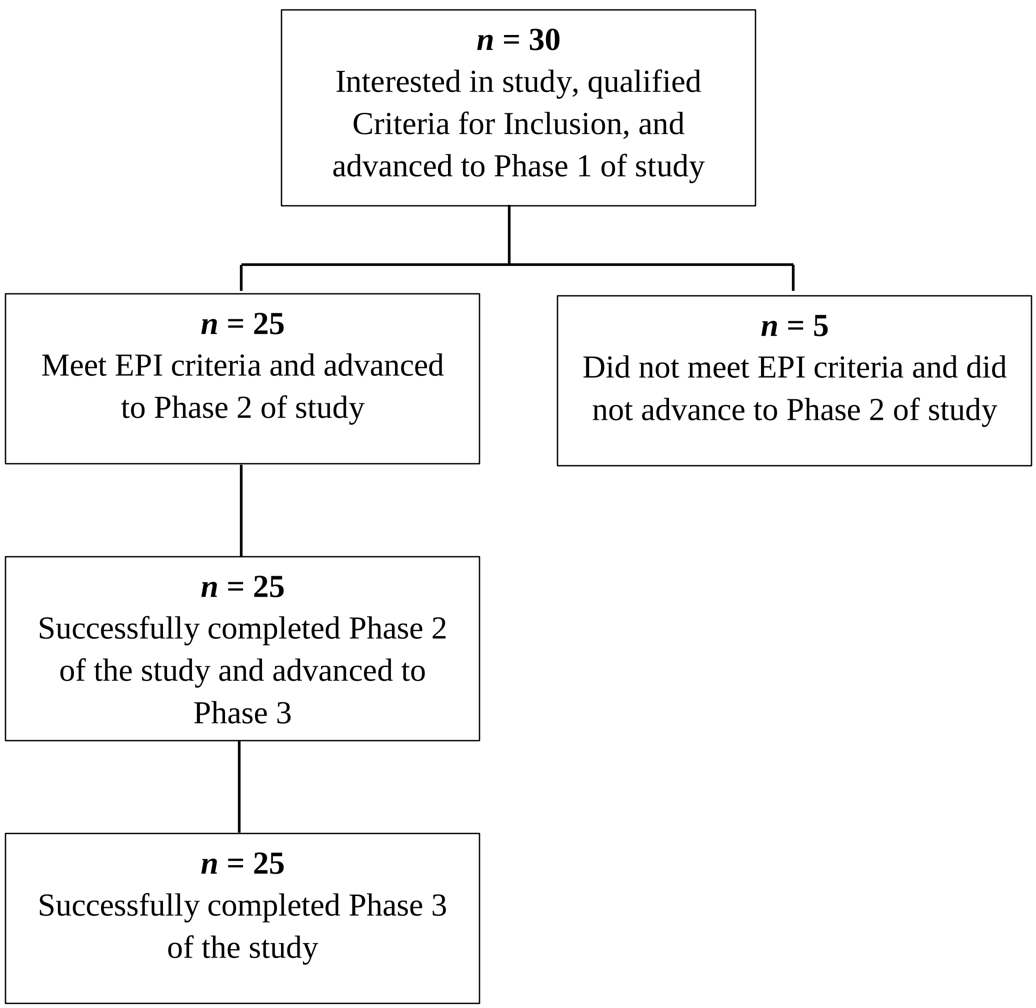

Figure 2. Participant recruitment flow diagram.

Participant characteristics. The mean age of the participants in this study was 22.6 (±2.4) years. Mean height of the participants was 167.3 (±6.5) centimeters (cm), mean bodyweight was 64.6 (±8.1) kilograms (kg), and mean body mass index (BMI) was 23.0 (±1.9). The mean extraversion level of the participants was 17.1 (±3.8), with a range of 6 to 22, and the mean neuroticism level was 10.1 (±3.3) with a range of 6-17. Complete demographic and anthropometric information of the participants is described in Table 1.

Table 1

Participant Characteristics

	$\bar{x}$	SD
Age (yrs)	22.6	2.4
Height (cm)	167.3	6.5
Weight (kg)	64.6	8.1
BMI (kg/m^2)	23.0	1.9
Right Thigh Circum (cm)	49.5	4.1
Left Thigh Circum (cm)	48.9	3.7
Right Limb Length (cm)	87.9	5.8
Left Limb Length (cm)	87.7	5.8
Right Skin Fold (mm)	25.0	4.7
Left Skin Fold (mm)	24.8	4.7
Right CSA (cm^2)	98.4	17.9
Left CSA (cm^2)	96.3	15.6
Right Hip ROM (°)	71.4	13.7
Left Hip ROM (°)	74.4	12.7
Sit & Reach (cm)	40.1	10.3
Extraversion Score	17.1	3.8
Neuroticism Score	10.1	3.3

Notes. All circumference and skin fold measures were taken from mid-thigh. All limb length measurements were taken from the anterior superior iliac spine to the lateral malleolus. CSA = cross-sectional area of the thigh. Sit and reach scores were measured by the modified sit and reach protocol. All personality scores were measured by the Eysenck Personality Inventory (EPI).

Counter Movement Jump Measures

Counter Movement Jump Performance. Only CMJ performance outcomes from each participant's highest peak CMJ height trial were used for analysis. The mean peak CMJ height was 29.1 (±4.7) cm, the mean peak CMJ power was 30.0 (±8.7) Watts/kilograms (W/kg), the mean peak CMJ force was 19.3 (±2.1) N/kilograms (N/kg), and the mean peak CMJ velocity was 182.0 (±40.8) centimeters/second (cm/sec).

Counter Movement Jump Muscle Activity. The peak EMG amplitudes for each muscle during the highest CMJ trial were normalized to the peak EMG amplitude recorded during the manual muscle testing procedure for that respective leg. Mean normalized peak EMG amplitudes for each muscle are described in Table 2. In addition, to create a single value to represent quadriceps and hamstring activation, these mean normalized values for each muscle were summed and averaged together according to muscle group (i.e., quadriceps or hamstrings). The mean right normalized peak quadriceps muscle activity was 2.25 (±0.73) and the mean right normalized peak hamstring muscle activity was 0.60 (±0.23). The mean left normalized peak quadriceps muscle activity was 1.93 (±0.60) and the mean left normalized peak hamstring activity was 0.52 (±0.19).

Table 2

Counter Movement Jump Normalized Muscle Activity

	R VL	**R RF**	**R VM**	**R BF**	**R ST**	**L VL**	**L RF**	**L VM**	**L BF**	**L ST**
AVG	3.03	1.54	2.19	0.61	0.59	2.19	1.30	2.31	0.44	0.60
SD	1.72	0.75	0.95	0.32	0.33	0.87	0.56	1.03	0.19	0.26

Notes. R VL = right vastus lateralis; R RF = right rectus femoris; R VM = right vastus medialis; R BF = right biceps femoris; R ST = right semitendinosus; L VL = left vastus lateralis; L RF = left rectus femoris; L VM = left vastus medialis; L BF = left biceps femoris; L ST = left semitendinosus.

Outcomes of Interest

Primary outcomes. Bivariate Pearson correlations were conducted to examine the relationships between extraversion (E) and CMJ performance outcomes of the highest CMJ trial. Extraversion was not significantly correlated to peak CMJ height (r = 0.084, p = 0.688), peak CMJ power (r = 0.140, p = 0.506), peak CMJ force (r = 0.241, p = 0.245), or peak CMJ velocity (r = 0.055, p = 0.793). The relationships between neuroticism (N) and CMJ measures were also examined through the use of bivariate Pearson correlations. Neuroticism was not significantly correlated to peak CMJ height (r = -0.091, p = 0.665), peak CMJ power (r = -0.077, p = 0.714), peak CMJ force (r = -0.113, p = 0.592), or peak CMJ velocity (r = -0.084, p = 0.689). The correlations between extraversion and CMJ performance outcomes, as well as neuroticism and CMJ performance outcomes are also described in Figure 3.

Primary Outcomes Correlations

		E	N	CMJHeight	CMJPower	CMJForce	CMJVelocity
E	Pearson Correlation	1	.160	.084	.140	.241	.055
	Sig. (2-tailed)		.445	.688	.506	.245	.793
	N	25	25	25	25	25	25
N	Pearson Correlation	.160	1	-.091	-.077	-.113	-.084
	Sig. (2-tailed)	.445		.665	.714	.592	.689
	N	25	25	25	25	25	25
CMJHeight	Pearson Correlation	.084	-.091	1	.281	.369	.233
	Sig. (2-tailed)	.688	.665		.173	.070	.262
	N	25	25	25	25	25	25
CMJPower	Pearson Correlation	.140	-.077	.281	1	.841**	.969**
	Sig. (2-tailed)	.506	.714	.173		.000	.000
	N	25	25	25	25	25	25
CMJForce	Pearson Correlation	.241	-.113	.369	.841**	1	.703**
	Sig. (2-tailed)	.245	.592	.070	.000		.000
	N	25	25	25	25	25	25
CMJVelocity	Pearson Correlation	.055	-.084	.233	.969**	.703**	1
	Sig. (2-tailed)	.793	.689	.262	.000	.000	
	N	25	25	25	25	25	25

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Figure 3. SPSS correlation matrix of the primary outcome variables.

Secondary outcomes. In order to examine the relationships between extraversion and peak muscle activity during the highest CMJ, bivariate Pearson correlations were conducted. These correlations are described in Figure 4. Extraversion was not significantly correlated to any of the peak muscle activity of the individual muscles of the right leg, or the collective muscles of the quadriceps (R Quad, $r = 0.245$, $p = 0.237$) and hamstrings (R Ham, $r = -0.346$, $p = 0.090$) of the right leg. Extraversion was also not significantly correlated to any of the peak muscle activity of the individual muscles of the left leg, or the collective muscles of the quadriceps (L Quad, $r = 0.217$, $p = 0.298$) and hamstrings (L Ham, $r = 0.034$, $p = 0.871$) of the left leg. However, the correlation between extraversion and the peak muscle activity of the left vastus lateralis (VL) was approaching levels of significance ($r = 0.350$, $p = 0.086$).

The relationships between neuroticism and peak muscle activity during the highest CMJ trial were also examined through the use of bivariate Pearson correlations. These correlations are also described in Figure 4. Neuroticism was significantly correlated to the peak muscle activity of the right semitendinosus (ST) ($r = 0.435$, $p = 0.030$). All other peak muscle activity of the individual muscles of the right leg, as well as the quadriceps (R Quad, $r = -0.019$, $p = 0.928$) and hamstring (R Ham, $r = 0.192$, $p = 0.358$) muscle groups of the right leg were not significantly correlated to neuroticism. Neuroticism was not significantly related to any of the peak muscle activity of the individual muscles or the left leg, or the collective muscles of the quadriceps (L Quad, $r = -0.185$, $p = 0.377$) and hamstrings (L Ham, $r = 0.204$, $p = 0.327$) of the left leg. However, the correlation between neuroticism and the muscle activity of the left biceps femoris (BF) muscle activity was approaching levels of significance ($r = 0.391$, $p = 0.053$).

Secondary Outcomes Correlations

		E	N	R_Quad	R_Ham	L_Quad	L_Ham
E	Pearson Correlation	1	.160	.245	-.346	.217	.034
	Sig. (2-tailed)		.445	.237	.090	.298	.871
	N	25	25	25	25	25	25
N	Pearson Correlation	.160	1	-.019	.192	-.185	.204
	Sig. (2-tailed)	.445		.928	.358	.377	.327
	N	25	25	25	25	25	25
R_Quad	Pearson Correlation	.245	-.019	1	.139	.489*	.374
	Sig. (2-tailed)	.237	.928		.508	.013	.065
	N	25	25	25	25	25	25
R_Ham	Pearson Correlation	-.346	.192	.139	1	.048	.421*
	Sig. (2-tailed)	.090	.358	.508		.818	.036
	N	25	25	25	25	25	25
L_Quad	Pearson Correlation	.217	-.185	.489*	.048	1	.454*
	Sig. (2-tailed)	.298	.377	.013	.818		.023
	N	25	25	25	25	25	25
L_Ham	Pearson Correlation	.034	.204	.374	.421*	.454*	1
	Sig. (2-tailed)	.871	.327	.065	.036	.023	
	N	25	25	25	25	25	25

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Figure 4. SPSS correlation matrix of the secondary outcome variables.

Tertiary outcomes. Additional data were collected during the course of this study to provide insight for possible CMJ performance outcomes. These data that displayed significant correlations to CMJ performance outcomes and/or peak muscle activity during the CMJ are displayed in Figures 5 and 6 (found at the end of the chapter), and are described in further detail in this section. All other additional physiological data collected (i.e., sit & reach, thigh circumference, limb length, total thigh muscle cross-sectional area) resulted in low correlations that were not significantly related to any CMJ performance measures or peak muscle activity during the CMJ.

One particular data set, hip ROM, displayed the strongest relationship to peak CMJ height. Both right and left hip ROM were significantly correlated to peak CMJ height (r = 0.539, p = 0.005; r = 0.510, p = 0.009, respectively). This relationship is also further displayed in Figure 5. However, neither right nor left hip ROM was significantly correlated to any of the other CMJ measures.

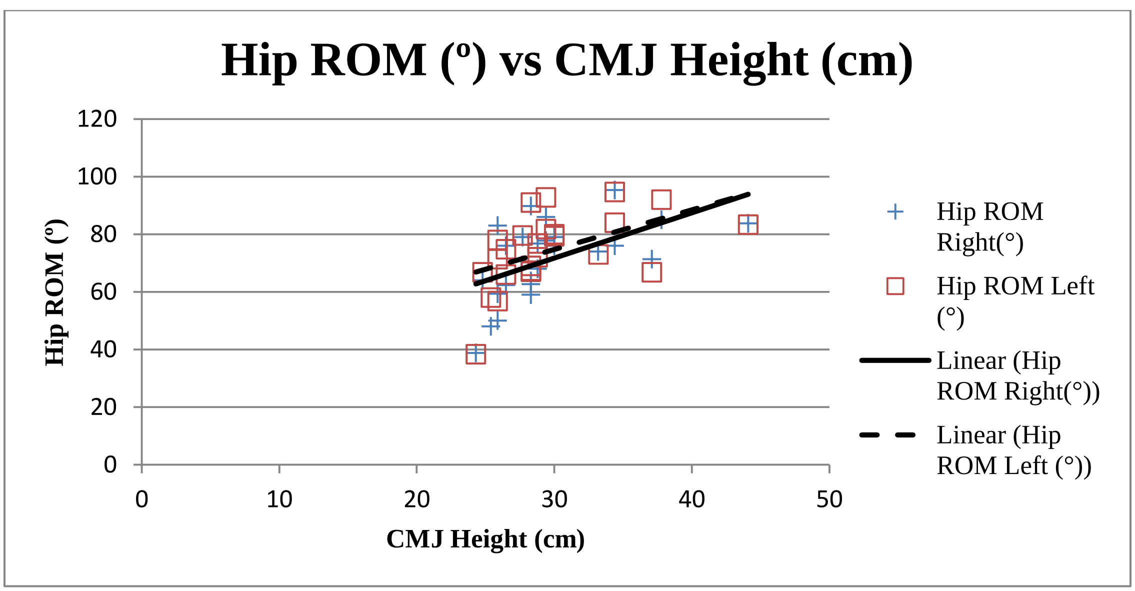

Figure 5. Hip ROM (º) vs. CMJ Height (cm). Right and Left Hip ROM were both significantly correlated to CMJ Height (r = 0.539, p = 0.005; r = 0.510, p = 0.009, respectively).

In addition, maximum knee flexion was significantly correlated to peak CMJ height (r = -0.600, p = 0.002). Correlations between peak CMJ power and maximum knee flexion, as well as peak CMJ force and maximum knee flexion, also approached levels of significance (r = -0.389, p = 0.055; r = -0.390, p = 0.054, respectively). The correlation between minimum knee flexion and peak CMJ height also approached levels of significance (r = -0.385, p = 0.057). Maximum knee flexion resembled the maximum angle of knee flexion during the squatting phase of the CMJ. Minimum knee flexion resembled the minimum angle of knee flexion (or the maximum angle of knee extension) during the propulsion phase of the CMJ.

The activity of one particular muscle, the VL, also displayed a strong relationship with peak CMJ height and peak CMJ force output. Both the right and left VL peak muscle activity were significantly correlated to peak CMJ height (r = 0.575, p = 0.003; r = 0.554, p = 0.004, respectively), as well as peak CMJ force output (r = 0.465, p = 0.019; r = 0.477, p = 0.016, respectively).

Finally, the skin folds of the right and left mid-thighs displayed a strong relationship with peak CMJ height. Both the right and left mid-thigh skin folds were significantly related to peak CMJ height (r = -0.417, p = 0.038; r = -0.399, p = 0.048, respectively).

Correlations

		CMJHeight	CMJForce	HipROM_R	HipROM_L	KneeMax	KneeMin
CMJHeight	Pearson Correlation	1	.369	.539**	.510**	-.600**	-.385
	Sig. (2-tailed)		.070	.005	.009	.002	.057
	N	25	25	25	25	25	25
CMJForce	Pearson Correlation	.369	1	.196	.201	-.390	.186
	Sig. (2-tailed)	.070		.348	.334	.054	.374
	N	25	25	25	25	25	25
HipROM_R	Pearson Correlation	.539**	.196	1	.949**	-.151	-.142
	Sig. (2-tailed)	.005	.348		.000	.471	.498
	N	25	25	25	25	25	25
HipROM_L	Pearson Correlation	.510**	.201	.949**	1	-.200	-.080
	Sig. (2-tailed)	.009	.334	.000		.337	.705
	N	25	25	25	25	25	25
KneeMax	Pearson Correlation	-.600**	-.390	-.151	-.200	1	.203
	Sig. (2-tailed)	.002	.054	.471	.337		.332
	N	25	25	25	25	25	25
KneeMin	Pearson Correlation	-.385	.186	-.142	-.080	.203	1
	Sig. (2-tailed)	.057	.374	.498	.705	.332	
	N	25	25	25	25	25	25

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Figure 6. SPSS correlation matrix of the tertiary outcome variables.

Correlations

		CMJHeight	CMJForce	R_VL	L_VL	SkinFold_R	SkinFold_L
CMJHeight	Pearson Correlation	1	.369	.575**	.554**	-.417*	-.399*
	Sig. (2-tailed)		.070	.003	.004	.038	.048
	N	25	25	25	25	25	25
CMJForce	Pearson Correlation	.369	1	.465*	.477*	-.123	-.118
	Sig. (2-tailed)	.070		.019	.016	.557	.574
	N	25	25	25	25	25	25
R_VL	Pearson Correlation	.575**	.465*	1	.796**	-.469*	-.437*
	Sig. (2-tailed)	.003	.019		.000	.018	.029
	N	25	25	25	25	25	25
L_VL	Pearson Correlation	.554**	.477*	.796**	1	-.447*	-.402*
	Sig. (2-tailed)	.004	.016	.000		.025	.046
	N	25	25	25	25	25	25
SkinFold_R	Pearson Correlation	-.417*	-.123	-.469*	-.447*	1	.964**
	Sig. (2-tailed)	.038	.557	.018	.025		.000
	N	25	25	25	25	25	25
SkinFold_L	Pearson Correlation	-.399*	-.118	-.437*	-.402*	.964**	1
	Sig. (2-tailed)	.048	.574	.029	.046	.000	
	N	25	25	25	25	25	25

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Figure 7. SPSS correlation matrix of the tertiary outcome variables (continued).

CHAPTER V: DISCUSSION

Introduction

Athletic performance and physical ability have been studied and quantified by researchers in an effort to enhance the capabilities and function of each for decades. Many of the measures used to examine and predict athletic performance and physical ability have been psychologically or physiologically based. Common psychological outcomes of interest are the personality characteristics of extraversion and neuroticism. Common physiological outcomes of interest are measures that quantify the proficiency of executing a gross movement task, such as a vertical jump. Measures often used to quantify such a task often include peak jump height and peak power production during the task.

The sport psychology literature has identified several relationships between extraversion and athletic performance. One identified relationship in the literature is that individuals who exhibit a higher level of extraversion, engage in more physical activity and display greater physical ability than individuals who exhibit a lower level of extraversion (Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965). Another identified relationship in the literature is that elite level athletes exhibit a high degree of extraversion in comparison to their less proficient counterparts (Briggs, Sandstrom, & Nettleton, 1979; Morgan & Johnson, 1978; Morgan, O'Connor, Ellickson, & Bradley, 1988).

The sport physiology literature has also identified several relationships between extraversion and measures of performance. One identified relationship in the literature is that individuals who exhibit a high degree of extraversion display a decreased motorneuronal excitability and a faster movement time during a reaction based test (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000; Pivik, Stelmack, & Bylsma, 1988; Stelmack & Pivik, 1996). Another identified relationship in the literature is that muscle activity levels during functional movements and the loading of a joint differ across personality groups (Chany, Parakkat, Yang, Burr, & Marras, 2006; Glasscock, Turville, Joines, & Mirka, 1999; Marras, Davis, Heaney, Maronitis, & Allread, 2000).

Due to the possible relationship of functional movement proficiency, movement time, and muscle activation patterns to extraversion level, these physiological mechanisms should be examined by researchers in order to possibly explain the aforementioned relationships between extraversion and physical ability and athletic performance observed in the literature. However, to date no study has yet examined these mechanisms during an athletic-based, gross functional movement.

As such, the purpose of the current study was to investigate a potential relationship between personality (i.e., extraversion & neuroticism) and counter movement jump (CMJ) performance (i.e., peak height, peak power, peak force, & peak velocity). A secondary purpose of this study was to examine a potential relationship between personality and muscle activity during the CMJ.

This study was divided into three phases of data collection. Phase 1 consisted of personality measurement, Phase 2 consisted of anthropometric measurements and Phase 3 consisted of the CMJ measurements. A total of 30 participants were recruited for this study, with 25 advancing on to the performance testing phases of the study (i.e., Phases 2 & 3). The primary outcomes of interest were the relationships between measures of personality, based upon the Eysenck Personality Inventory (EPI), and peak height, peak power, peak force, and peak velocity of the CMJ. Secondary outcomes of interest were the relationships between measures of personality and muscle activity of the quadricep and hamstring muscle groups during the highest CMJ trial. Tertiary outcomes of interest were select physiological variables that may provide further mechanistic insight into these potential relationships.

According to the results of this study, there were no significant relationships between personality and any of the CMJ performance measures (i.e., peak height, peak power, peak force, peak velocity). In addition, there were no significant relationships between personality and muscle activity levels during the CMJ trial that resulted in the highest vertical jump. However, there were several tertiary variables that displayed a significant relationship to the CMJ performance measures, including right and left hip range of motion (ROM), maximum knee flexion, and skin folds of the right and left thighs.

Based on these results, both the primary and secondary hypotheses of this study were rejected. The following chapter will review the individual findings of this study and relate them to the previous literature. Subsequently the scientific and practical significance of this study will be discussed. Finally, the limitations and suggestions for future research will be addressed.

Primary Outcomes

The group average of the female participants' CMJ peak height in the current study (29.1 ±4.7 cm) was consistent with that of the previous literature. Nuzzo, Anning, and Scharfenberg (2011) reported trial averages of 30.0 (±4.5) cm, 29.6 (±4.8) cm, and 30.0 (±4.6) cm among females with the use of the same Myotest Sport unit as the current study. Thus, the observed peak CMJ heights of the female participants in the current study can be compared to other values from previous research.

Extraversion and CMJ performance measures. A common element involved in proficient athletic ability is the capacity to generate power and force during a gross movement task. These elements are evident during the jumping, sprinting, pushing, and other actions observed during various sporting events. Thus, if a relationship between these types of gross movement actions and extraversion level were identified, it would provide mechanistic reasoning to the previously established relationships between personality and athletic ability. With this hypothesis in mind, this study investigated the action of a counter movement jump, and quantified the overall ability of the task by examining the peak height of the highest CMJ trial. This study also examined the variables that contribute to this task (i.e., power, force, & velocity), in order to identify a mechanistic variable(s) that may explain why relationships between personality and athletic ability have been observed in the previous literature.

The primary outcome of this study was demonstrating that extraversion level displayed no significant relationship with any of the examined CMJ performance measures (i.e., peak height, peak power, peak force, peak velocity) during the highest CMJ trial of each participant. This finding contradicted the primary hypothesis of this study. According to the results of this study, personality does not appear to be significantly related to the measured physiological variables of the CMJ.

However, this finding is relevant to the body of literature as it contributes to a gap that has existed pertaining to the relationship between extraversion and athletic ability. It has been routinely demonstrated in the literature that athletes who exhibit a high degree of extraversion are generally more proficient and successful than their less extraverted counterparts (Morgan et al., 1988). However, this was the first study to investigate physiological variables that may result in this observed relationship. This study's findings suggest that although there may be a relationship between athletic ability and extraversion level, it does not appear to manifest itself during a CMJ. Since vertical jump ability is a common element of proficient athletic ability, this finding is not consistent with the previous literature as the data did not identify an observable relationship between athletic ability and extraversion level.

The results of the current study are also in conflict with other previously suggested hypotheses linking personality and movement time. Doucet and Stelmack (1997) found that extraverts displayed a significantly ($p < 0.01$) shorter movement time than introverts, during a simple reaction time test. Based upon these findings, Doucet and Stelmack (1997) hypothesized that introverts and extraverts ultimately display equal peak velocities during a movement, but that extraverts are able to accelerate to that velocity faster than introverts. This hypothesis implies that individuals who exhibit a high degree of extraversion are capable of greater power production than individuals who exhibit a lesser degree of extraversion, as they are able to create a greater acceleration of their force production during the movement. However, this hypothesized relationship was not observed in the present study.

It is possible that the results of the current study may be due to the type of movement task. The majority of the previous studies have utilized a simple movement task requiring the movement of an individual's hand and/or arm to move from one point to another as fast as possible (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000; Stahl

& Rammsayer, 2004; Stahl & Rammsayer, 2008). It is possible that the complexity of the CMJ accounted for the inconsistency between the current findings and those in the previous literature. A relationship may be observed if the individual was required to move from one point to another as fast as they could during a gross, athletic movement (e.g., a 20 yard sprint) and future studies should keep this in mind.

Other researchers suggest that the use of a stimulus command may be important. The current study used a simple auditory tone for a task stimulus and the participant's only command was a 'go' command. It is possible that if a stimulus requiring the individual to decipher between a 'go' command and a 'no-go' command was utilized, a significant relationship may have been observed. For example, if one auditory tone indicated 'go' and another tone indicated 'no-go'. This type of stimulus command has been utilized several times previously in the literature and has exhibited significant relationships between extraversion and movement time (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000; Stahl & Rammsayer, 2008). It is possible that personality and performance are differentiated, to some extent, based on the stimulus to initiate a task.

A relationship between physical ability and extraversion has also been demonstrated in the literature. It has been suggested that individuals who exhibit a high degree of extraversion also exhibit a high degree of physical ability and skill (Kane, 1964). The current study attempted to investigate this relationship through the examination of the gross movement skill of a CMJ. However, no relationship between peak CMJ height and extraversion level was identified in this study. This finding suggests that a skill such as vertical jump ability is not related to extraversion level.

However, other gross movement skills, such as sprinting ability or balance ability, may still display a relationship to extraversion level, and should be further investigated.

Neuroticism and CMJ performance measures. The second primary outcome of this study was demonstrating that neuroticism level displayed no significant relationship with any of the examined CMJ measures (i.e., peak height, peak power, peak force, peak velocity) during the highest CMJ trial of each participant. Although the primary personality trait of interest in this study was extraversion, the dual relationship between the two traits makes it difficult to examine the traits independently.

Previous research has also identified a relationship between neuroticism level and athletic ability. Morgan et al. (1988) observed a significant negative correlation between neuroticism level and 10,000 meter running performance among elite middle distance runners (r = -0.50, p = 0.03). Due to the fact that neuroticism level seems to have a negative effect on athletic ability, steps were taken to ensure any effect on CMJ performance measures were as a result of extraversion level, and not a factor of neuroticism level. In order to accomplish this agenda, this study limited the inclusion of participants, based upon their neuroticism score on the EPI, to within a range of 6-17. This step was taken in order to include only participants who were within one standard deviation of the published normative mean for neuroticism level. Thus, extremes on both ends of the scale were excluded, and the participant sample would be reflective of the published *normative* sample of participants. This was done as a precautionary measure, as the main outcome of interest of the current study was the relationship between extraversion and CMJ performance measures, and not neuroticism and CMJ performance measures.

Since there has been a previously identified relationship between neuroticism level and athletic ability, the relationship between neuroticism level and CMJ performance measures were also still examined. However, no significant relationships between neuroticism level and CMJ performance measures were displayed. This finding appears to contradict previous research in the literature. However, it should be once again noted that this was not the primary outcome of interest for this study. If further investigation of the potential relationship between neuroticism and athletic ability are of interest for researchers, the methods of participant inclusion and exclusion should reflect that interest.

Secondary Outcomes

In the current study, muscle activity was analyzed and categorized according to whether the muscle acted as an agonist or an antagonist to the CMJ task. The quadricep muscles (i.e., vastus lateralis, rectus femoris, & vastus medialis) were considered the agonist muscle group and the hamstring muscles (i.e., biceps femoris & semitendinosus) were considered the antagonist muscle group. The most active individual agonist muscles during the highest CMJ trial were the vastus lateralis (VL) muscles. The right VL exhibited an average normalized peak amplitude of 3.03 and the left VL had an average normalized peak amplitude of 2.19. The most active individual antagonist muscles during the highest CMJ trial were the semitendinosus (ST) muscles. The right and left ST had an average normalized peak amplitude of 0.59 and 0.60, respectively. Previous research performed by Sandberg, Wagner, Willardson, and Gerald Smith (2012) and Salles, Baltzopoulos, and Rittweger (2011) also demonstrated similar muscle activation patterns during a vertical jump.

Extraversion and measures of muscle activity. In an attempt to examine the muscle activity that may contribute to the hypothesized relationship between extraversion and CMJ performance measures, peak muscle activity of the quadricep and hamstring muscle groups were measured via surface electromyography (EMG). Thus, the secondary outcome of this study was demonstrating that no significant relationships were displayed between extraversion level (as measured by the EPI) and normalized peak muscle activity of the quadricep or hamstring muscle groups (as measured via EMG) during the highest CMJ trial of each participant.

Previous research has identified relationships between extraversion level and the peripheral mechanisms of fine motor movement. Thus, muscle activity was utilized as a method for examining the potential relationships between extraversion level and the gross motor movements of the CMJ. Although no significant relationships were identified in this study, the results still fill a relevant gap in the literature concerning the peripheral mechanisms of motor movement in relation to extraversion level.

As previously stated, Doucet and Stelmack (1997) found that extraverts displayed a significantly ($p < 0.01$) shorter movement time than introverts, during a simple reaction time test. As a follow up to this study, Doucet and Stelmack (2000) examined the cognitive processing speed between extraverts and introverts during a simple reaction test. This was accomplished through the use of electroencephalogram (EEG) recordings to measure event-related potentials (ERPs) that are elicited in response to an auditory stimulus. Upon recognition of this auditory stimulus, the participant was to move their finger from one point to another as fast as possible. Doucet and Stelmack (2000) found no significant relationship between the measured event-related potentials (i.e., P3 wave latency or N1 wave amplitude) and extraversion level. Based upon these results, the researchers hypothesized that any relationship between movement time and extraversion level would have to directly attributed to mechanisms occurring at the peripheral motor nerve of the participants.

Other researchers have also demonstrated possible relationships between extraversion level and the peripheral mechanisms of motor movement. Stahl and Rammsayer (2008) demonstrated that extraverts display a significantly ($p < 0.05$) shorter response-locked lateralized readiness potential (LRP-R) than introverts during a simple reaction test. Stahl and Rammsayer (2008) also demonstrated that extraverts generally displayed a shorter, although not statistically significant ($p < 0.07$), response-locked EMG latency than introverts. Based upon these results, Stahl and Rammsayer (2008) concluded that extraverts displayed faster peripheral motor processing than introverts during a simple reaction test.

With this previous research in mind, EMG was utilized in the current study to examine a potential relationship between extraversion level and peripheral motor processing during the CMJ task. Although no significant relationships were identified, these results are still relevant to the literature as they demonstrate that the previously observed relationships between extraversion level and movement are not observed during a gross, explosive movement task. These previously identified relationships may only be evident during fine motor movement tasks. However, further research should be conducted investigating possible relationships between extraversion and other types of gross movement tasks (e.g., sprinting, balancing). It should also be noted that the current study only examined peak amplitudes during the highest CMJ trial, and not the latency time of the EMG measures. Based upon research of Stahl and Rammsayer (2008), possible relationships could also have been observed if a reaction time-oriented task was employed. Thus, personality differences in gross movement may in fact manifest at the initiation of the task (e.g., CMJ latency) and not the ultimate magnitude of the task (e.g., CMJ height).

Neuroticism and measures of muscle activity. As previously stated, neuroticism was not the primary outcome of interest of this study. However, due to the simultaneous relationship between neuroticism level and athletic ability, the relationships between neuroticism level (as measured by the EPI) and muscle activity of the quadricep and hamstring muscle groups (as measured via EMG) during the highest CMJ trial were examined. As such, another secondary outcome of this study was demonstrating that there were no observed significant relationships between neuroticism level and the muscle activity of the quadricep and hamstring muscle groups during the highest CMJ trial. However, the individual normalized peak muscle activity hamstring muscle of the right semitendinosus (ST) was significantly correlated to neuroticism level ($r = 0.435$, $p = 0.030$), and the correlation between left bicep femoris (BF) muscle activity and neuroticism level was approaching levels of significance ($r = 0.391$, $p = 0.053$).

Currently, there is no known research investigating potential relationships between neuroticism level and muscle activity during a gross or fine movement task. As such, results of the current study also fill an obvious gap in the literature pertaining to possible relationships between neuroticism level and muscle activity during a movement task. However, it should once again be noted that due to the steps taken in order to control for neuroticism level amongst the participants recruited in this study, relationships between neuroticism and muscle activity during the CMJ tasks should be viewed with caution.

Although there is currently no research in the literature investigating possible relationships between neuroticism level and muscle activity during a movement task, there is previous research identifying relationships between muscle activity and other personality types. Glasscock et al. (1999) demonstrated that individuals with Type A personality exhibit a significantly ($p < 0.05$) higher degree of integrated muscle activation in the tricep muscles during maximum isometric and isokinetic elbow flexion tasks than individuals with Type B personality. The ratio of integrated muscle activity in the tricep muscles to the bicep muscles during elbow flexion was also significantly ($p < 0.05$) higher in individuals with Type A personality than with Type B personality. This finding suggests that individuals with Type A personality display higher antagonist muscle activity during a single-joint movement than individuals with Type B personality.

A similar relationship was observed in the current study as individuals with a high degree of neuroticism displayed a higher degree of peak hamstring muscle activation (i.e., right semitendinosus & left biceps femoris) during the CMJ task. In this type of task (i.e., jumping), the hamstring muscles are considered the antagonist muscle group. Thus, a similar muscle activation pattern, or *coactivity*, was observed between individuals who display a Type A personality and individuals who display a high degree of neuroticism. Individuals who display a high degree of neuroticism are generally considered to be emotionally liable and over-responsive (H.J. Eysenck & Eysenck, 1968). These types of personality characteristics are commonly shared among Type A individuals as well, thus, similar comparisons can be drawn.

Glasscock et al. (1999) also demonstrated that maximum torque produced or precision of torque held did not differ between Type A or Type B personality groups. Similarly, none of the CMJ measures of this current study were significantly related to neuroticism level. Consequently, overall performance of either elbow flexion or CMJ was not dependent upon personality factors. However, the coactivity patterns that occur during the actions of the task may be related to personality factors.

The functional implications that this coactivation muscle pattern has on a task remain unclear. Based upon this current study and Glasscock et al. (1999), there is not a determined impact on performance. However, during the load of a joint abnormal muscle activation patterns may result in a detrimental loading pattern of that joint, which may substantially increase the risk of injury during a task.

In other studies previous researchers have investigated the effect of personality on muscle activation patterns and subsequent spinal loading shears on individuals during gross movement tasks. Marras et al. (2000) demonstrated that individuals who exhibited introversion personality preferences displayed a significantly ($p < 0.05$) increased lateral shear force (27.2%) and compression force (13.7%) during a gross movement loading task, than all other examined personality types. This difference was attributed to a significantly ($p < 0.05$) higher external oblique muscle activation (18.7%). These abnormally high lateral shear and compression forces during the loading task were considered to reflect coactivation of the oblique and erector spinae muscles due to the perceived stress of the task and situation. Marras et al. (2000) also hypothesized that this increased muscle activation among individuals who exhibit introversion personality preferences may ultimately lead to an increased risk for injury.

Other studies have demonstrated relationships between personality and spinal loading. Chany et al. (2006) investigated several personality groups including intuitors, sensors, perceivers, and judgers. Chany et al. (2006) demonstrated that intuitors displayed a significantly ($p = 0.0206$) higher anterior posterior shear than sensors. In addition, Chany et al. (2006) demonstrated that perceivers had a significantly ($p < 0.0001$) higher (16%) spinal compression and a significantly ($p < 0.0001$) higher (12%) lateral shear than judgers. Although the studies performed by Marras et al. (2000) and Chany et al. (2006) did not specifically examine the personality trait of neuroticism, clear relationships were identified between muscle activation and subsequent shear forces placed onto the body during gross movement tasks differ between personality groups.

Based upon the results demonstrated in the current study and previous studies, further research should be done to investigate possible relationships between neuroticism level and muscle coactivation patterns during various gross movement tasks. In addition, identification of possible injury risk factors that are related to neuroticism during these tasks should be further investigated.

Tertiary Outcomes

In an attempt to provide additional insight a possible relationship between personality and the physiological measures of the CMJ, additional physiological data were collected and analyzed. These data include height, weight, thigh circumference, limb length, thigh skin folds, thigh muscle cross-sectional area, hip range of motion (via goniometry), hip flexibility (via sit & reach), and maximum and minimum knee flexion during the CMJ trial. Several of these variables resulted in high correlations that were significantly related to the CMJ performance measures, or the peak muscle activity of the

CMJ trial, and/or the measures of personality. As such, these variables will be further discussed in the following section. All other physiological data resulted in low correlations that were not significantly related to the CMJ performance measures, or peak muscle activity of the CMJ trial, and/or the measures of personality.

Hip Range of Motion. Right and left hip ROM for each participant was examined through the use of manual goniometry. Hip ROM measurement consisted of the participant performing an active straight leg raise while her range of motion was measured. This flexibility measurement was investigated in order to explore if a relationship between active ROM through a joint (e.g., hip) was related to the overall performance and power production during a gross movement task. If an individual has a larger ROM to move their force output through, this may result in a greater power production.

Both right and left hip ROM were significantly correlated to peak CMJ height, but not any of the other CMJ performance measures ($r = 0.539$, $p = 0.005$; $r = 0.510$, $p = 0.009$). Hip ROM was the highest and most significant observed correlation between a physiological variable and any of the CMJ performance measures. This finding is intriguing as it suggests that greater hip ROM is positively related a greater peak CMJ height, but not greater power, force, or velocity outputs during the task. Furthermore, vertical jump height has long been considered a function of human power output. That is, the greater the power output, the greater the vertical jump height. Previous research has even attempted to predict the power output from an individual based upon their vertical jump height (Harman, Rosenstein, M.T., Frykman, Rosenstein, R.M., & Kraemer, 1991).

However, the current study demonstrated no significant relationship between peak CMJ height and peak CMJ power output ($r = 0.281$, $p = 0.173$). This finding, coupled with the significant relationship between hip ROM and CMJ height, suggests that optimal CMJ height is contingent upon a variety of factors and not just the peak power output of the individual. One such factor appears to be the lower body range of motion that the individual is able to fully utilize, thus, flexibility may be an important factor.

In previous studies, researchers have investigated whether flexibility is related to vertical jump performance. Bazett-Jones, Gibson, and McBride (2008) demonstrated that chronic static hamstring stretching over six weeks did not improve vertical jump performances in women track and field athletes. The current study supports their finding as hamstring flexibility, as measured by the sit and reach task, was not significantly related to peak CMJ height. However, what these two measures (i.e., sit & reach, active knee extension test) fail to fully characterize is the overall ROM used during the jumping task. There may be other functional limitations occurring besides hamstring flexibility that hinder the ROM of the hip joint during the CMJ task, thus resulting in a lower jump height. For example, if the participant's gluteal muscles display a great deal of tightness, the participant's ability to undergo hip flexion may be hindered. If the participant's ability to undergo hip flexion is hindered, their hip ROM will be decreased. According to the results of the current study, if a participant displays a smaller hip ROM, they may also exhibit a lower peak CMJ height.

There are also other tightness-related muscle factors that may influence CMJ performance. For example, if the length of the plantar flexor muscles were limited, then a participant would likely have limited ability to undergo dorsiflexion of the foot. As a result, the limited dorsiflexion will negatively impact the ability to squat down during the counter movement phase of a vertical jump, resulting in a smaller hip ROM during the task, and possibly a lower peak CMJ height. This hypothesis of specific flexibility needs for optimal CMJ performance has also been demonstrated in the literature. Sandberg et al. (2012) demonstrated that only stretching the antagonist muscles involved in a vertical jump task (i.e., hip flexors & dorsiflexors) resulting in significantly higher vertical jump height and power output ($p = 0.011$; $p = 0.005$, respectively). These findings suggest that specific areas of flexibility are important factors in vertical jump performance. In addition, the relationships between specific types of stretching interventions and protocols and CMJ performance should be further examined.

The study has suggested that flexibility is in fact related to CMJ performance. Hunter and Marshall (2002) demonstrated performance increases in CMJ height, but no improvements in other types of vertical jumps (e.g., drop jump) after flexibility training. The novel of approach of Hunter and Marshall (200) was that this study utilized several different stretching techniques that targeted several different muscle groups (e.g., hip extensors, hip adductors, plantarflexors). What the researchers ultimately concluded is that the depth of the counter movement was an important factor in CMJ height. Based upon these results, an increase in overall lower body flexibility may result in a greater hip ROM. A greater hip ROM may in turn result in a greater counter movement depth and thus, CMJ height.

Maximum knee flexion. Results of the current study also demonstrated a similar significant relationship between counter movement depth and peak CMJ height. Maximum knee flexion (i.e., the depth of the counter movement) was significantly correlated to peak CMJ height ($r = -0.600$, $p = 0.002$). That is, the lower the counter movement depth, the greater peak CMJ height. This observed relationship coincides with the previous findings of Hunter and Marshall (2002), as well as others.

Salles et al. (2011) demonstrated that peak CMJ height was significantly related ($P < 0.001$) to the depth of the counter movement, with the highest CMJ resulting from a counter movement depth of 90º of knee flexion. Furthermore, results of Salles et al. (2011) suggest that the magnitude of the counter movement has a significant effect on CMJ height, force, and torque, but not power. This is intriguing, because as previously stated, vertical jump height has long been used to assess power output in a gross movement task. However, based upon the results of Salles et al. (2011) and the results of this current study, actual power output seems to be a fairly ubiquitous factor.

Salles et al. (2011) also reported that during counter movements of little knee flexion (e.g., 50º), the CMJ action primarily depends on the ankle plantar flexors. While during counter movement of greater knee flexion (e.g., 90º), the CMJ action primarily depends on the quadricep and hamstring muscle groups. Salles et al. (2011) contend that the greater the depth of the counter movement, the greater activation of the quadriceps muscle group, and thus the greater the CMJ height.

Although it is easy to formulate the assumption that if a person undergoes a greater counter movement depth during a CMJ, they would be more likely to display a greater hip ROM in order to accomplish this greater depth, the results from the current study suggest otherwise. Both right and left hip ROM were not significantly related to maximum knee flexion ($r = -0.151$, $p = 0.471$; $r = -0.200$, $p = 0.337$, respectively). This suggests that although both of these variables may play an important role in CMJ height, they may also act independently of each other.

Based upon the results of this study and the previous research in the literature, future studies should investigate the confounding relationship between vertical jump height and power output. Specifically, relationships between peak CMJ height and hip ROM and the depth of the counter movement during a CMJ, should be further examined. In addition, different types of stretching intervention protocols and techniques should be investigated.

CMJ performance and muscle activity. As previously stated, both the right and left the VL muscles displayed the greatest muscle activity during the highest CMJ trial. This type of muscle activation pattern was expected and is in accordance with the previous literature (Sandberg et al., 2012; Salles et al., 2011). This right and left VL muscle activity was also significantly correlated to peak CMJ height ($r = 0.575$, $p = 0.003$; $r = 0.554$, $p = 0.004$, respectively) and peak CMJ force output ($r = 0.465$, $p = 0.019$; $r = 0.477$, $p = 0.016$, respectively). However, the muscle activation of the VL muscles was not significantly related to the peak CMJ power output. Once again, the power output of the CMJ seems to be influenced by several different physiological factors, possibly including muscle activation patterns.

CMJ performance and skin folds. Another interesting significant relationship was between the skin folds of the mid-thigh and peak CMJ height. Both right and left thigh skin folds were significantly negatively correlated to peak CMJ height ($r = -0.417$, $p = 0.038$; $r = -0.399$, $p = 0.048$, respectively). That is, the smaller the skin fold thickness, the greater the peak CMJ height. However, once again, this variable was significantly related to peak CMJ height, but not significantly related to peak CMJ power or any other CMJ performance measures.

Skin fold thickness if often considered a reference of the amount of subcutaneous adipose tissue (i.e., fat) that surrounds that body segment. Essentially, the smaller skin fold thickness, the smaller amount of subcutaneous adipose tissue. Generally, people with a smaller amount of subcutaneous adipose tissue have a larger amount of lean muscle mass. However, another interesting aspect of this relationship was the fact that skin fold thickness of both the right and left thighs were not significantly related to the total muscle cross-sectional area (CSA) of either the right or left thigh ($r = -0.160$, $p = 0.444$; $r = -0.119$, $p = 0.572$, respectively). Based upon these results, skin fold thickness was not significantly related to the total thigh muscle CSA.

In addition, total thigh muscle CSA was not significantly related to any of the examined CMJ performance measures. This presents a confounding relationship between lean muscle of the thigh and CMJ performance. The relationship between skin fold thickness and peak CMJ height suggests muscle plays a role, but the total thigh muscle CSA relationship does not. However, it is also possible that the amount of muscle mass is more localized than simply the total thigh CSA.

Previous research conducted by Earp et al. (2010) demonstrated that lateral gastrocnemius (LG) muscle thickness is the greatest predictor of CMJ power and height ($R^2 = 0.201$, $p = 0.014$). However, Earp et al. (2010) only examined the thickness VL and LG muscles. In addition, Earp et al. (2010) contradicts previous literature demonstrating that as the counter movement of a jump increases (e.g., a CMJ), the contribution of the quadricep and hamstring muscles increases (Salles et al., 2011).

Future research should attempt to create a more complete picture of the relevance of the various muscles involved during a vertical jump task. For example, a ratio of the total muscle CSA of the entire quadriceps to the total muscle CSA of the entire gastrocnemius or hamstrings, may further explain optimal musculature required for optimal CMJ performance. In general, further investigation of the relationship between CMJ performance and thigh skin folds and thigh muscle CSA should be conducted.

Summary

The results of the current study have demonstrated that no significant relationship exists between the personality traits of extraversion and neuroticism and CMJ performance. Thus, the primary hypothesis of this study was rejected. The results of the curent study have also demonstrated no significant relationship between the level extraversion and neuroticism and muscle activity of the quadricep and hamstring muscle groups during the CMJ trial. Thus, the secondary hypothesis of this study was rejected as well. There is a possible, although a weak, relationship between neuroticism level and specific hamstring muscle activation (i.e., right ST & left BF muscles) during the CMJ task. However, the current study was not specifically investigating the relationship between neuroticism and muscle activity during the CMJ task. It is possible that if the personality trait of neuroticism was specifically examined, a more significant relationship would be observed. It is also possible that other physiological characteristics may be flushed out.

The results of the current study also suggest that hip ROM and maximum knee flexion during the counter movement phase of the CMJ are the most significant variables related to peak CMJ height. Furthermore, these variables display no significant relationship to any of the other CMJ performance measures, including power output. This is a rather confounding finding as an increased hip and knee ROM during the CMJ does not seem to create any increased amount of power output, force output, or velocity output, however, ultimately results in a higher peak CMJ height. These results suggest that an increased hip and knee ROM may possibly allow for a more efficient movement pattern during the CMJ and thus, a greater peak height, with less demand on power or force output to achieve the same height.

Lastly, the results of the current study suggest that thigh skin fold thickness is significantly related to peak CMJ height, but no other CMJ performance variables. In addition, the total thigh muscle CSA was not significantly related to any of the CMJ performance measures or thigh skin fold thickness. This suggests that there may be a relationship between muscle mass and CMJ height, but it may exist in a more specific nature than just simply total thigh muscle CSA (i.e., quadricep or hamstring muscle CSA).

Significance

The results of the current study are significant due to the fact that they fill a gap in the literature concerning the physiological nature of extraversion during a gross movement task. This was the first study of its kind to examine the relationships between extraversion level and a functional, sport specific task (i.e., the CMJ). The results of the current study also identified several other physiological variables that do hold significant relationships to CMJ performance and should be further explored.

Scientific significance. The results of the current study hold scientific significance as they demonstrate that extraversion is not significantly related to the performance of a CMJ. The current study also identified that extraversion level is not significantly related to the electrophysiological mechanisms (i.e., muscle activity) during a CMJ, however, that neuroticism level may in fact display possible significant relationships.

The current study also identified in several instances, a confounding relationship between CMJ power output and CMJ height. Several relationships (i.e., hip ROM, knee flexion, thigh skin folds) were significantly related to CMJ height, but not power output. This calls into question that actual ability of the CMJ to reflect power output, as well as the overall function of power output in relation to vertical jump ability.

Practical significance. The results of the current study hold practical significance as they suggest that extraversion does not have a significant relationship to CMJ performance. However, the current study does demonstrate a significant relationship between hip and knee ROM and CMJ height. Based upon these results, practitioners should focus on increasing their client's hip ROM in order to increase their CMJ height. In addition, practitioners should instruct their clients to undergo a greater amount of knee flexion during the counter movement phase of the CMJ, in order to achieve a maximum jump height. The general goal of practitioners should be to increase the quality of the movement through the overall CMJ ROM, and not simply one aspect of the movement (e.g., hamstring flexibility). Practitioners in the fields of strength and conditioning, as well as physical therapy and athletic training, can utilize these results as the CMJ is not only a sport-related task, but is also a gross, functional movement.

Limitations

A potential limitation of the current study was the small sample size that was not evenly distributed across extraversion level. Although the current study had a large range of extraversion level, 6 to 22, the average extraversion level of the participants was 17.1, which is higher than the published norm of 15.2. It is possible that a larger, more evenly distributed (i.e., across personality) sample size would have yielded more significant and meaningful relationships between CMJ performance and/or muscle activity and personality.

Limitations related to experimenter error also existed throughout the current study. Many of the physiological measurements include an inherent degree of experimenter error, such as skin folds, circumference and length measurements, and goniometry. Limitations of equipment error due to interference between EMG electrodes, as well as participant error during the completion of the EPI questionnaires also existed. The motivation level of the participants to give their maximum effort during the CMJ trials may also have resulted in participant error.

Other limitations include the delimitations of only examining female participants, requiring a minimum weekly activity level for participation, and individuals within the ages of 18-29 years. In addition the delimitations required to reduce the risk of participant injury by excluding individuals who were taking prescribed medication for a symptomatic illness, had an injury, surgery, or bone abnormalities on their knees, hips, or ankles in the last year, had a heart condition or any chest pain, were pregnant, suffered from dizziness, and/or had hearing impairments. Due to these delimitations, the results of the current study are not generalizable outside of this sample population and further research is needed.

Recommendations for Future Research

Future research should specifically examine the relationship between neuroticism and performance during a gross movement task. In addition, the relationships between the electrophysiological mechanisms and neuroticism level during a gross movement task should be further explored. Although no significant relationships between extraversion and CMJ performance were demonstrated, the current study only investigated the magnitude (e.g., peak height) of the task and not the onset of the task (e.g., latency).

Future research should also investigate the relationships between hip and knee ROM and peak CMJ height. In addition, the confounding relationships between flexibility interventions and CMJ performance should also be further investigated, with more focus placed on improving the overall quality of the movement through a ROM, instead of simple flexibility tasks (e.g., sit and reach).

Lastly, future research further should investigate the relationship between muscle mass and CMJ. Specifically, the relationship between CMJ performance and the individual muscle groups of the quadriceps and hamstrings should be explored. It is possible that a ratio of quadricep muscle mass to hamstring muscle mass may exhibit a more significant relationship to CMJ performance, versus the total thigh muscle mass.

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APPENDICES

APPENDIX A

Recruitment Flyer

UWM UNIVERSITY of WISCONSIN MILWAUKEE

RESEARCH STUDY PARTICIPANTS NEEDED!

A study investigating the differences in counter movement jump performance between introvert and extraverts is being conducted by researchers in the Human Performance & Sport Physiology Lab

- **Eligible Participants Include:**
  - FEMALES between 18-29 years of age.
  - Individuals who:
    - Engage in regular exercise (e.g., 2-3 times/week).
    - Are not a member of a competitive, elite level sports team (e.g., UWM athletics team).
    - are not taking prescribed medication for a symptomatic illness, have not had an injury, surgery, or bone abnormalities on their knees, hips, or ankles, do not have a heart condition or any chest pain, are not pregnant, do not suffer from dizziness, and/or do not have hearing impairments.
- This study contains of 3 phases – two total testing sessions. Estimated total commitment time is 1.5 – 2 hours.
- Participants will complete the Eysenck Personality Inventory questionnaire.
- Participants will perform a counter movement jump (vertical jump) and researchers will measure various performance and physiological variables.
- Participants will have their muscle activity monitored through the use of electromyography (EMG).
- This study is completely non-invasive & no side effects/injuries are expected.

Please contact David Cornell (dcornell@uwm.edu) if you are interested in participating. All testing sessions will be held in the Human Performance & Sport Physiology Lab in Room 365 of the Pavilion.

Counter Movement Jump Study David Cornell **dcornell@uwm.edu**

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Counter Movement Jump Study David Cornell **dcornell@uwm.edu**

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Counter Movement Jump Study David Cornell **dcornell@uwm.edu**

APPENDIX B

Criteria for Inclusion Questionnaire

Human Performance & Sport Physiology Lab
Department of Kinesiology
University of Wisconsin-Milwaukee
3409 N. Downer Ave
Pavilion – Physical Therapy, Room 365
Milwaukee, WI 53211

Eligible to Participate: YES NO

ID#:________________

Date:________________

Criteria for Inclusion Questionnaire

Counter movement jump performance differences between introverts and extraverts – David Cornell Thesis

The following questions will help determine if you meet the criteria for inclusion into the study. It is important that you accurately answer each question.

Please answer the following questions with a yes or no response.	YES	NO
1. Are you currently between the ages of 18 and 29 years old?		
2. Do you consider yourself a physically active individual?		
3. Have you engaged in at least 150 minutes of moderate intensity physical activity or at least 75 minutes of vigorous intensity physical activity per week, for the last 6 months?		
4. In the last year (including now), have you trained for or competed in a competitive sport or another competitive physical activity (e.g., a marathon)?		
5. Do you currently take any prescribed medications for treatment of a symptomatic illness or condition?		
6. Do you have any serious symptomatic ankle, knee, or hip trauma requiring medical attention within the last 3 months?		
7. Have you had any surgery on your hip, knee, and/or ankle within the last year?		
8. Do you have any bone, joint, or muscle abnormalities (i.e. arthritis, muscle pain)?		
9. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?		
10. Do you feel pain in your chest when you do physical activity?		
11. In the past year, have you had chest pain when you are <u>not</u> doing physical activity?		
12. Do you often feel faint or have severe spells of dizziness?		
13. Do you feel any pain in your joints and/or limbs when jumping or stretching?		
14. Do you require the use of an assistive or supportive device to perform physical activity (e.g., knee or ankle brace)?		

15. Are you currently pregnant?		
16. Do you know of any reason why you should not do physical activity?		
17. Are you a member of a competitive, organized athletic team (i.e. UW-M team)?		
18. Do you have any hearing impairments or difficulty hearing certain auditory tones?		

APPENDIX C

Informed Consent Document

UNIVERSITY OF WISCONSIN – MILWAUKEE
CONSENT TO PARTICIPATE IN RESEARCH

1. General Information

Study title:
Counter movement jump performance differences between introverts and extraverts.

Person in Charge of Study (Principal Investigator):
Kyle T. Ebersole, Ph.D., LAT (PI/Adviser)
Associate Professor, Department of Kinesiology
College of Health Sciences

David J. Cornell, B.S., CSCS (Thesis)
Masters of Kinesiology Graduate Student, Department of Kinesiology
College of Health Sciences

2. Study Description

You are being asked to participate in a research study. Your participation is completely voluntary. You do not have to participate if you do not want to.

Study description:
The primary purpose of this study is to investigate the possible differences in counter movement jump performance between extravert and introvert personality groups. The secondary interest of this study is to investigate possible physiological mechanisms that may contribute to any performance differences. This will be accomplished by examining differences in various physiological measurements (i.e., height, weight, thigh circumference, etc.), hip joint flexibility through use of a modified sit and reach test, and hip range of motion through use of a goniometer. In addition, the researchers will examine possible differences in muscle activation via surface electromyography (EMG) (a device that records the electrical activity of a muscle) recordings of various muscles of the quadriceps and hamstring muscle groups during the counter movement jump (CMJ) task. The literature suggests that possible psychophysiological differences between the introvert and extravert personality groups exist. However, to date, there is no current research investigating these possible performance differences during a functional or gross motor movement task. The goal of this study is determine if these performance differences exist, and if so, attempt to explain the mechanistic reasoning.

All activities in this study will take place in the Human Performance & Sport Physiology Laboratory (HPSPL) located in Room 365 of the Pavilion. This study will involve 3 phases. Participants will be recruited until a total of 60 have completed all 3 phases. The 60 participants (30 introverts, 30 extraverts) will be females between the ages of 18 and 29. Participants will be recreationally active, but not currently training for or competing in a competitive sport (e.g., a NCAA Division I sport) or activity (e.g., a marathon). The time commitment for participants will depend on how far they advance through the study's three phases. In Phase 1 the participants will complete all required paperwork and the researchers will administer the Eysenck Personality

Inventory (EPI). The EPI will assign each participant into either the introvert, extravert, or non-participating groups. If the participant is assigned to the non-participating group, their participation in this study is over. Phase 1 is expected to last 10-15 minutes. In Phase 2 the introvert and extravert group participants will become familiar with the CMJ task and the researchers will answer any questions the participants may have. The researchers will also measure and record the various physiological measurements. Phase 2 is expected to last 20-30 minutes. In Phase 3 the researchers will conduct all functional and power performance testing. This includes hip joint flexibility, hip joint range of motion, CMJ performance, and all EMG recordings. Phase 3 is expected to last 60 minutes.

3. Study Procedures

What will I be asked to do if I participate in the study?
If you fulfill the criteria for inclusion requirements and agree to participate, you will be asked to come to Human Performance & Sport Physiology Laboratory located in Room 365 of the Pavilion for all testing phases. This study will be divided into three phases. The phases are described in detail below and will be completed in the order listed.

Phase 1:

- During Phase 1, you will read and give informed consent to the study protocol. You will be allowed to ask questions prior to signing the informed consent document.
- Once you have signed the informed consent, and been included in to the study, you will be given a study ID (such as EXS1) that will be used to code all of your data collected during the study.
- You will also complete an exercise history questionnaire. This questionnaire assesses the amount and what kinds of exercise and physical activity you have and are currently partaking in.
- You will then complete the Eysenck Personality Inventory (EPI). Based on the scores from this questionnaire, you will be assigned to either the introvert, extravert, or non-participating groups. If you are assigned to the non-participating group, your involvement in this study is completed and you will be free to leave. The researchers will retain your personality data from the EPI, and used as part of data analysis for EPI scores in this population.

Phase 2:

- Your height, body weight, age, and birthdate will be measured and recorded and your body mass index (BMI) will be calculated and recorded.
- Your thigh circumference, limb length, and thigh skinfold will be measured and recorded. Based on these values the researchers will calculate your estimated total thigh muscle cross-sectional area (CSA), which is a measure of muscle size.
- The researchers will then verbally explain the protocol of the counter movement jump (CMJ) task and the other functional tests that will be administered during Phase 3 of this study (see below). You will also be provided the opportunity to practice the CMJ until you are comfortable performing the jump.
- The researchers ask that you refrain from smoking (or any other tobacco product) and caffeine intake the four hours preceding Phase 3, as well as any heavy resistance training the 48 hours preceding Phase 3.

Phase 3:

- During Phase 3, you will first perform a brief, five minute warm-up on a bicycle ergometer with a light, self-selected, resistance level.
- Your hip range of motion will then be measured with a goniometer (a kind of ruler). This measurement will take place while you are lying on your back and raise your leg (with knee completely straight) as far as comfortably possible and hold that position while a goniometer measurement is recorded.
- Your hip joint flexibility will be measured through a sit and reach test. This test will require you to sit on the ground with your back against the wall, with your legs straight out and your feet touching the measurement device (with your shoes off). The researchers will then determine your starting position for this test. You will then place your dominant hand over your non-dominant hand and lean forward, pushing the meter on the device as far forward as you can without 'bouncing' back and forth.
- During the CMJ task, EMG measures will be recorded. EMG is a non-invasive method to measure the electrical properties of muscle. The hair on 6 places on each of your thighs (3 in front, 2 in back, and one on the outside of your knee), and 1 place on your upper calf will be removed with a brand-new disposable razor (a new razor will be used for each participant). After removal of the hair, your skin will be cleaned with rubbing alcohol. Both legs will be tested. These methods are necessary to make sure the information from the electrodes is clear. If you prefer, you can perform the shaving procedure yourself. Once cleaned, 2 electrodes (7/8"x7/8" stickers) will be taped to the cleaned areas on your thigh. Wires from the electrodes are then connected to a device (Noraxon Telemyo 2400T G2) that measures and records the electrical activity of the muscles.
- You will then be seated in a comfortable chair with your knees at 90° of flexion. The researchers will conduct manual testing to determine your maximum voluntary contraction (MVC) values for knee extension and knee flexion. This will be done by having you push and pull your leg into the researchers' hands as hard as you can. These values will be used to normalize your EMG amplitudes during the CMJ trials.
- Lastly, you will be fitted with the Myotest Sport unit and belt. The Myotest unit is a small accelerometer based device that will measure the height, force output, work output, and velocity of each of your CMJ trials. This device is attached to a neoprene belt that you will have around your waist.
- You will then perform one practice CMJ trial to ensure that the Myotest Sport unit and the EMG amplitudes are being recorded properly. The researchers will also validate that you are using correct form during the CMJ.
    - CMJ Instructions:
        - You will begin each jump (trial) with your hands on your hips.
        - You will listen for the sound of the second beep (stimulus) from the researchers.
        - You will squat in a downward motion and propel yourself upward, and jump off the ground as high and as fast as you can, with your hands remaining on your hips.
- You will perform CMJ trials until three successful CMJ trials are recorded. The researchers will record information from the Myotest and EMG data between each successful trial. A trial will be considered unsuccessful if: you start your movement before the proper stimulus (false start), you remove your hands from your hips during the jump, the Myotest Sport unit cannot properly assess the trial, or the EMG data is not properly recorded.
- After three successful trials are recorded, the Myotest Sport unit and EMG electrodes will be removed and your commitment to this study will be over.

4. Risks and Minimizing Risks

What risks will I face by participating in this study?
There are no expected risks for participating in this research study. It is possible, although very unlikely, that you may experience minor musculoskeletal injuries such as muscle strain, muscle soreness, and/or tightness associated with the sit and reach, straight leg raise, and CMJ tasks. Since part of the inclusion criteria for this study was participation in regular exercise, it is expected that the risks associated with these tasks are unlikely, and that this risk is no different than any other form of physical activity. The researchers will attempt to avoid possible musculoskeletal injuries by having you properly warm-up before starting data collection. It is also possible that the shaving and/or electrodes cause minor skin irritation. To avoid this, you can apply skin lotion and/or triple antibiotic ointment (Neosporin) to site of the electrodes.

Although an injury due to participation in this study is unlikely, participants suffering an injury will be directed to Norris Health Center (UWM students only) or to a personal physician. Any injury requiring emergency medical care will be managed by activating the emergency response system (i.e., dialing 9-911 on campus phone). You will be responsible for any medical cost associated with any injury occurring as a result of participation in this study.

5. Benefits

Will I receive any benefit from my participation in this study?
There are no benefits to you other than to further research.

6. Study Costs and Compensation

Will I be charged anything for participating in this study?
You will not be responsible for any of the costs from taking part in this research study.

Are subjects paid or given anything for being in the study?
You may receive extra credit in your HMS 400 and/or HMS 270 course by participating in this study. However, the awarding of any possible extra credit is at the discretion of the professor of the class(es). No monetary compensation of any kind will be awarded.

7. Confidentiality

What happens to the information collected?
All information collected about you during the course of this study will be kept confidential to the extent permitted by law. We may decide to present what we find to others, or publish our results in scientific journals or at scientific conferences. Only the PI (Ebersole), co-PI (Cornell), or

approved graduate students assisting with the study will have access to the information. However, the Institutional Review Board at UW-Milwaukee or appropriate federal agencies like the Office for Human Research Protections may review this study's records.

Information used to personally identify you will be collected (name and contact info) for this project and will only be used to contact you during this study. This information will not be used in the data analysis, nor will it be released to others. Your identity will be kept confidential, except as might be required by law. You will be given a study ID code (such as EXS1) that will be used to code all of your data collected during the study. An identity key file containing your name, study ID code, and contact information will be stored (in a locked file in the Human Performance & Sport Physiology Laboratory in PAV 365) separate from all collected data for the purpose of contacting you during the study. All experimental data and associated questionnaires will be stored in a file based on your unique study ID code (i.e., EXS1) and separate from any personally identifying contact information. At no time will the coded data files include names or contact information. In addition, all data from the participants in the non-participating group will be kept, but will not be analyzed in this study. Results obtained from this research study will be disseminated in journal articles and scientific meetings. The data will be stored in a locked file cabinet in PAV 365 for 10 years for future use.

8. Alternatives

Are there alternatives to participating in the study?
There are no known alternatives available to you other than not taking part in this study

9. Voluntary Participation and Withdrawal

What happens if I decide not to be in this study?
Your participation in this study is entirely voluntary. You may choose not to take part in this study. If you decide to take part, you can change your mind later and withdraw from the study. You are free to not answer any questions or withdraw at any time. Your decision will not change any present or future relationships with the University of Wisconsin Milwaukee.

If you voluntarily withdraw or are withdrawn from the study prior to its completion, we will use the information collected to that point. Withdrawal from the study prior to your commitment being completed will result in no extra credit awarded. Withdrawal from the study will in no way affect your class standing as a student at UW-Milwaukee.

10. Questions

Who do I contact for questions about this study?
For more information about the study or the study procedures or treatments, or to withdraw from the study, contact:

David J. Cornell
Masters of Kinesiology Graduate Student
College of Health Sciences
Dept. of Kinesiology
PAV – PT, Room 375
dcornell@uwm.edu

or

Kyle T. Ebersole, Ph.D.
College of Health Sciences
Dept. of Kinesiology
PAV – PT, Room 356
(414) 229-6717
ebersole@uwm.edu

Who do I contact for questions about my rights or complaints towards my treatment as a research subject?
The Institutional Review Board may ask your name, but all complaints are kept in confidence.

Institutional Review Board
Human Research Protection Program
Department of University Safety and Assurances
University of Wisconsin – Milwaukee
P.O. Box 413
Milwaukee, WI 53201
(414) 229-3173

11. Signatures

Research Subject's Consent to Participate in Research:
To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study, you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read or had read to you this entire consent form, including the risks and benefits, and have had all of your questions answered, and that you are 18 years of age or older.

____
Printed Name of Subject/ Legally Authorized Representative

____ _____________________
Signature of Subject/Legally Authorized Representative Date

Research Subject's Consent to Audio/Video/Photo Recording:
Not applicable. There will be no audio/video/photo recording in this study.

Principal Investigator (or Designee)

I have given this research subject information on the study that is accurate and sufficient for the subject to fully understand the nature, risks and benefits of the study.

Printed Name of Person Obtaining Consent	Study Role
Signature of Person Obtaining Consent	Date

APPENDIX D

Eysenck Personality Inventory Questionnaire

ID #: ______

EYSENCK PERSONALITY INVENTORY

FORM B

By H. J. Eysenck
and Sybil B. G. Eysenck

INSTRUCTIONS

Here are some questions regarding the way you behave, feel, and act. After each question is a space for answering "Yes," or "No."

Try and decide whether "Yes," or "No" represents your usual way of acting or feeling. Then blacken in the space under the column headed "Yes," or "No."

Work quickly, and don't spend too much time over any question; we want your first reaction, not a long drawn-out thought process. The whole questionnaire shouldn't take more than a few minutes. Be sure to answer all questions. Now turn the page over and begin. Work quickly, and remember to answer every question. There are no right or wrong answers, and this isn't a test of intelligence or ability, but simply a measure of the way you behave.

Section of Answer Column Correctly Marked

Yes No

Yes No

EPI 001

E N L

1. Do you like plenty of excitement and bustle around you .... Yes No
2. Have you often got a restless feeling that you want something but do not know what? .... Yes No
3. Do you nearly always have a "ready answer" when people talk to you? .... Yes No
4. Do you sometimes feel happy, sometimes sad, without any real reason? .... Yes No
5. Do you usually stay in the background at parties and "get-togethers"? .... Yes No
6. As a child did you always do as you were told immediately and without grumbling? .... Yes No
7. Do you sometimes sulk? .... Yes No
8. When you are drawn into a quarrel, do you prefer to "have it out" to being silent hoping things will blow over? .... Yes No
9. Are you moody? .... Yes No
10. Do you like mixing with people? .... Yes No
11. Have you often lost sleep over your worries? .... Yes No
12. Do you sometimes get cross? .... Yes No
13. Would you call yourself happy go lucky ? .... Yes No
14. Do you often make up your mind too late? .... Yes No
15. Do you like working alone? .... Yes No
16. Have you often felt listless and tired for no good reason? .... Yes No
17. Are you rather lively? .... Yes No
18. Do you sometimes laugh at a dirty joke? .... Yes No
19. Do you often feel "fed-up"? .... Yes No
20. Do you feel uncomfortable in anything but everyday clothes? .... Yes No
21. Does your mind often wander when you are trying to attend closely to something? .... Yes No
22. Can you put your thoughts into words quickly? .... Yes No
23. Are you often lost in thought? .... Yes No
24. Are you completely free of prejudices of any kind? .... Yes No
25. Do you like practical jokes? .... Yes No
26. Do you often think of your past?" .... Yes No
27. Do you very much like good food? .... Yes No
28. When you get annoyed do you need someone friendly to talk to about it? .... Yes No
29. Do you mind selling things or asking people for money for some good cause? .... Yes No
30. Do you sometimes boast a little? .... Yes No
31. Are you touchy about some things? .... Yes No
32. Would you rather be at home on your own than go to a boring party? .... Yes No
33. Do you sometimes get so restless that you cannot sit long in a chair? .... Yes No
34. Do you like planning things carefully, well ahead of time? .... Yes No
35. Do you have dizzy spells? .... Yes No
36. Do you always answer a personal letter as soon as you can after you have read it? .... Yes No
37. Can you usually do things better by figuring them out alone than by talking to others about it? .... Yes No
38. Do you ever get short of breath without having done heavy work? .... Yes No
39. Are you an easygoing person, not generally bothered about having everything "just-so"? .... Yes No
40. Do you suffer from nerves? .... Yes No
41. Would you rather plan things than do things? .... Yes No
42. Do you sometimes put off until tomorrow what you ought to do today? .... Yes No
43. Do you get nervous in places like elevators, trains or tunnels? .... Yes No
44. When you make new friends, is it usually you who makes the first move, or does the inviting? .... Yes No
45. Do you get very bad headaches? .... Yes No
46. Do you generally feel that things will sort themselves out and come right in the end somehow? .... Yes No
47. Do you find it hard to fall asleep at bedtime? .... Yes No
48. Have you sometimes told lies in your life? .... Yes No
49. Do you sometimes say the first thing that comes into your head? .... Yes No
50. Do you worry too long after an embarrassing experience? .... Yes No
51. Do you usually keep "yourself to yourself" except with very close friends? .... Yes No
52. Do you often get into a jam because you do things without thinking? .... Yes No
53. Do you like cracking jokes and telling funny stories to your friends? .... Yes No
54. Would you rather win, than lose a game? .... Yes No
55. Do you feel self-conscious when you.are with superiors? .... Yes No
56. When the odds are against you, do you still usually think it worth taking a chance? .... Yes No
57. Do you often get "butterflies in your stomach" before an important occasion? .... Yes No

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED ALL THE QUESTIONS.

APPENDIX E

Exercise History Questionnaire

Human Performance & Sport Physiology Laboratory
University of Wisconsin-Milwaukee

Exercise History Questionnaire

Participant ID Code: __________ Date: __________

1. In the last 6 months, how many days a week have you spent 30 minutes or more in moderate to strenuous exercise?

   0 1 2 3 4 5 6 7

2. If you have been exercising, what activity have you done most often?

   Walk Swim Dance Bike Run Other

3. If you answered **Other** for question 2, what is the primary other activity that you have done?

4. If you have been exercising, how long (minutes) has each exercise session been?

   Less than 5 5-19 20-30 More than 30

5. If you have been exercising, would you say the intensity has been:

   Easy Moderate Somewhat Hard Hard

6. If you have never exercised or are no longer exercising, what is your main reason?

7. Have you (or are you currently) trained/competed for a sport or other competitive physical activity (e.g., a marathon) in the last year?

   Yes No

8. Did you compete in an organized, competitive sport at one point of your life?

   Yes No

9. If yes for Question 8, what type of sport and what position (or event) did you play (if applicable)?

   Sport: ____

   Position: ____

10. Do you frequently lift moderately heavy objects as part of your daily activities?

    Yes No

11. Do you frequently climb stairs as part of your daily activities?

    Yes No

12. Do you regularly engage in informal physical activities?

    Yes No

    a. If you circled **Yes** for question 12, please specify:

APPENDIX F

Description of Testing Protocol

Testing Session Protocol

Before the participant can advance to Phase 1, the participant must pass the Criteria for Inclusion Questionnaire (see Appendix A).

Phase 1 Protocol:

- The participant will read and sign the Informed Consent paperwork, agreeing to the study's protocol (see Appendix B).
- The personality inventory of the participant will then be assessed via the Eysenck Personality Inventory (EPI).
- The participant will complete the Exercise History Questionnaire (Appendix G)
- If the participant gives Informed Consent and meets the desired neuroticism level (EPI), the participant will advance into Phase 2 of the study. If the participant does not, their participation in the study is over.

Phase 2 Protocol:

- The researchers will explain the testing protocol to the participant and answer any questions.
- The participant will be allowed to practice the counter movement jump to become familiarized with the movement.
- The researchers will measure height and weight, and record other required anthropometrics of the participant.

Phase 3 Protocol:

- The participant will first perform a brief, five minute warm-up on the bicycle ergometer with a light, self-chosen, resistance level.
- The researchers will measure hip range of motion (ROM) of the participant via the goniometer.
- The researchers will measure hip flexibility via the modified sit and reach test.
- The participant will then be fitted with the portable EMG unit and connecting electrodes.
- The participant will then be fitted with the Myotest unit and belt.

Counter Movement Jump Instructions

- The participant will begin each jump (trial) with their hands on their hips.
- The participant will be instructed to listen for the sound of the second beep (stimulus) from the researchers. The participant will squat in a downward motion and propel themselves upward, and jump off the ground as high and as fast as they can, with their hands remaining on their hips.
- The participants will perform this vertical jump three successful times. The researchers will record information from the Myotest unit and EMG data between each successful trial.
- A trial will be considered unsuccessful and will be subsequently discarded if:
    - The participant starts their movement before the proper stimulus (false start)

- The participant removes their hands from their hips
- The Myotest unit cannot properly assess the trial
- EMG data is not properly recorded

APPENDIX G

Institutional Review Board Protocol Summary

Protocol Summary

Instructions: In order to review research involving human subjects, the UWM IRB requires the completion and submission of the New Study Application Form and a Protocol Summary. The following guidelines are designed to help researchers develop a comprehensive yet concise research protocol to facilitate timely review by the IRB. Please note, Capstone, thesis, dissertation, grant, and funding proposals cannot be submitted as, or in lieu of, this Protocol Summary as they do not contain all the required information (45CFR46).

Each Section must be completed unless directed otherwise. Incomplete forms will delay the IRB review process and may be returned to you. Enter your information in the **colored boxes**. The boxes will expand as you type.

SECTION A: Title and Date	
Note that the study title must be the same on all study documents (e.g., consents, advertisements, grants, etc.). If not, a reason must be given in the Protocol Summary Form Section I.	
A1. Project Title:	Counter movement jump performance differences between introverts and extraverts.
A2. Today's Date:	

SECTION B: Project Purpose/ Research Question/ Objectives

In non-technical language, address the following:

1) Area of the research
2) Describe the purpose/objective
3) Significance of the research is
4) Any relevant literature pertaining to the proposed research study

1) Athletic performance and physical ability have been have been widely studied by physiologists and psychologist alike. In the field of sport psychology, the literature has demonstrated that differences in athletic and physical ability exist between personality groups, most notably between introverts and extraverts (Briggs, Sandstrom, & Nettleton, 1979; Hendry, 1975; Kane, 1964; Kane, 1970; Tillman, 1965). In general, extraverts display a greater physical ability and athletic performance than introverts. In addition, elite athletes generally display a higher degree of extraversion than other less proficient athletes (Eagleton, McKelvie, & deMan, 2007).

   The field of physiology has also investigated potential differences between introvert and extravert personality groups. This literature has demonstrated possible differences in cognitive processing speed between introverts and extraverts (Stahl & Rammsayer, 2004; Stahl & Rammsayer, 2008). In addition, the literature has demonstrated that introverts exhibit a greater motoneuronal excitability than extraverts and that extraverts display a faster movement time than introverts (Doucet & Stelmack, 1997; Doucet & Stelmack, 2000; Pivik, Stelmack, & Bylsma, 1988; Stelmack & Pivik, 1996). This has lead researchers to speculate that extraverts may be more proficient at gross movement tasks and may possibly display a greater power output than introverts (Stelmack, 1990). However, there is currently no study investigating these possible differences. In addition, there is no study investigating the functional mechanistic reasoning behind these possible psychophysiological differences between introverts and extraverts.

The literature has also demonstrated differences in muscle activation between personality groups (Chany, Parakkat, Yang, Burr, & Marras, 2006; Glasscock, Turville, Joines, & Mirka, 1999; Marras, Davis, Heaney, Maronitis, & Allread, 2000). Specifically, differences in antagonist muscle activation have been demonstrated between personality groups. These differences may explain the possible physical ability and athletic differences that have been previously identified in the literature, as well as identify possible differences in injury risk due to improper loading of the joints. However, these differences have not been specifically investigated between the extravert and introvert personality groups during a gross, power production task.

2) The *purpose* of the proposed study is to investigate potential differences in power production via the counter movement jump (CMJ) between introvert and extravert personality groups. The secondary purpose is to investigate possible electrophysiological mechanisms that may explain these differences in power output between introverts and extraverts. The *hypotheses* of this study are that extraverts will produce a greater power output as determined by the CMJ than introverts and that the difference between personality groups is a function of muscle activity/co-activity differences. The researchers will examine these two purposes in two manners:

1. Determine if extraverts produce a greater power output than introverts by CMJ performance differences. This will be done through the use of a Myotest Sport unit, which is a small accelerometer based device that will measure the height (cm), force output (N/kg), work output (W/kg), and velocity (cm/sec) of the CMJ.

2. Determine if extraverts produce a greater agonist muscle activity than introverts, and/or if introverts produce a greater antagonist muscle activity than extraverts, during the CMJ. This will be done through the use of surface electromyography (EMG). EMG will assess the muscle activity level (via EMG amplitude) of the quadriceps and hamstrings muscle groups.

3) Scientific Significance:
This study will add to the scientific literature by investigating possible power output and performance differences between introvert and extravert personality groups during a gross movement and functional task, such as jumping. This study will also investigate possible electrophysiological differences between introvert and extravert personality groups during a gross movement and functional task. This study will be the first of its kind doing so.

Practical Significance:
The study will also be the first of its kind to investigate the possible functional and mechanistic differences in CMJ performance between extravert and introvert personality groups. If this study demonstrates that there are differences between these groups, it will further the understanding of why extraverts are generally more proficient at gross movement physical abilities and athletics. This study may also contribute possible mechanistic reasoning behind functional movement differences between introvert and extravert personality groups. If so, this could contribute to the fields of physical therapy and rehabilitation as it would demonstrate functional movement differences amongst individuals that practitioners may have to take into account when treating/diagnosing.

4) Briggs, C. A., Sandstrom, E. R., & Nettleton, B. (1979). An approach to prediction of performance using behavioral and physiological variables. *Perceptual and Motor Skills*, *49*(4), 843-848.
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Eysenck, H. J. (1963). Biological basis of personality. *Nature*, *199*, 1031-1034.
Eysenck, H. J., & Eysenck, S. B. G. (1968). *Manual for the eysenck personality inventory*. San Diego, CA: Educational and Industrial Testing Service.
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Glasscock, N. F., Turville, K. L., Joines, S. B., & Mirka, G. A. (1999). The effect of personality type of muscle coactivation during elbow flexion. *Human Factors*, *41*(1), 51-60.
Hendry, L. B. (1975). Personality & movement: A university study. *Journal of Human Movement Studies*, *1*(1), 19-23.
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Pivik, R. T., Stelmack, R. M., & Bylsma, F. W. (1988). Personality and individual differences in spinal motor excitability. *Psychophysiology*, *25*(1), 16-24.
Stahl, J., & Rammsayer, T. (2004). Differences in the transmission of sensory input into motor output between introverts and extraverts: behavioral and psychophysiological analyses. *Brain and Cognition*, *56*, 293-303.
Stahl, J., & Rammsayer, T. (2008). Extroversion-related differences in speed of premotor and motor processing as revealed by lateralized readiness potentials. *Journal of Motor Behavior*, *40*(2), 143-154.
Stelmack, R. M. (1990). Biological bases of extraversion: psychophysiological evidence. *Journal of Personality*, *58*(1), 293-311.
Stelmack, R. M., & Pivik, R. T. (1996). Extraversion and the effect of exercise on spinal motoneuronal excitability. *Personality Individual Differences*, *21*(1), 69-76.
Stelmack, R. M., & Plouffe, L. (1983). Introversion-extraversion: the bell-magendie law revisited. *Personality and Individual Differences*, *4*(4), 421-427.
Tillman, K. (1965). Relationship between physical fitness and selected personality traits. *Research Quarterly*, *36*(4), 483-489.

SECTION C: Recruitment and Consent/Assent

Describe the following:

1) How the **recruitmen**t will take place. E.g., through flyers, beginning announcement for X class, referrals, random telephone sampling, etc.
2) **Inclusion** criteria. E.g., age, gender, health status/condition, ethnicity, location, English speaking, etc.
3) **Exclusion** criteria. E.g., age, gender, health status/condition, ethnicity, location, English speaking, etc.

4) How **consent/assent** will take place. E.g., in person, online web survey, "request to waive consent" as this is secondary data analysis only, etc.
   a. If participants do not speak English as a first language or might have trouble comprehending the consent, describe the process for obtaining consent (e.g., translated consent, verbal consent, etc.).

1) **RECRUITMENT:** Participants will be recruited through flyers posted in approved places on the UWM campus and word of mouth across the Milwaukee community. Participants will also be recruited and offered extra credit for participation in various undergraduate courses in the Dept. of Kinesiology. Responses to solicitation will be voluntary.

2) **INCLUSION:** Participants will be between the ages of 18-29. All participants will be female. Participants will be included based on their self-reported responses to the Criteria for Inclusion Questionnaire. Participants will be assigned to either the introvert, extravert, or non-participating group, based on the Eysenck Personality Inventory (EPI). Recruitment will continue until 30 participants are assigned into the extravert group and 30 participants are assigned into the introvert group, for a total of 60 participants.

3) **EXCLUSION:** All participants will be screened with the Criteria for Inclusion Questionnaire which includes specific questions regarding lower extremity injuries and possible contraindications to physical activity. Participants will be excluded if they are taking prescribed medication for a symptomatic illness, had an injury, surgery, or bone abnormalities on their knees, hips, or ankles, have a heart condition or any chest pain, are pregnant, suffer from dizziness, have hearing impairments, are currently or have trained or competed in a competitive sport (e.g., Division I sports team) or physical activity (e.g., a marathon) in the last year , or do not meet the minimum requirements of physical activity as described by the American College of Sports Medicine (ACSM). No special expertise is needed to screen the participants.

4) **CONSENT:** Research staff will talk to interested candidates via phone or in-person at the Human Performance & Sport Physiology Laboratory (HPSPL) to determine if they have any of the conditions explained in the exclusionary criteria that would make them ineligible for participation. The research staff will make inclusion/exclusion decisions based on the self-reported (yes or no) presences of specific conditions. If a participant answers "yes" to any of questions 4-18, or "no" to any of questions 1-3, they will be excluded. Participation will be strictly voluntary and participants may withdraw from the study at any time.

SECTION D: Data Collection and Design

In non-technical language, address the following:

1) Chronologically state the **study activities**. Describe both the activities conducted by the PI and the research participants. (E.g., screening, survey, taking a test, answering questions in an interview, completing a specific task, tasks on a computer, running on a treadmill, debriefing, etc.). If videotaping, photographs, or audiotaping will take place, explain for what and why.
2) Explain how the **data will be analyzed** or studied (i.e. quantitatively or qualitatively) and how the **data will be reported** (i.e. aggregated, anonymously, pseudonyms for participants, etc.).

1) Individuals who meet the criteria for inclusion and agree to participate, will be asked to come to Human Performance & Sport Physiology Laboratory located in Room 365 of the Pavilion for all testing phases. This study will be divided into three phases. The phases are described in detail below and will be completed in the order listed.

   A. Phase 1:
   - During Phase 1, the participant will read and give informed consent to the study protocol. The participant will be allowed to ask questions prior to signing the informed consent document.
   - Once the participant has signed the informed consent, and been included in to the study, they

will be given a study ID (such as EXS1) that will be used to code all of their data collected during the study.
- The participant will also complete an exercise history questionnaire. This questionnaire assesses the amount and what kinds of exercise and physical activity they have and are currently partaking in.
- The participant will then complete the Eysenck Personality Inventory (EPI). Based on the score from this questionnaire, the participant will be assigned to either the introvert (E score < 15), extravert (E score > 15), or non-participating (E score = 15) groups. If the participant is assigned to the non-participating group, their involvement in this study is completed and they will be free to leave. The researchers will retain all personality data from the EPI from participants assigned to the non-participating group, and this data will used as part of data analysis for EPI scores in this population.

B. Phase 2:
- The participant's height, body weight, age, and birthdate will be measured and recorded. The participant's body mass index (BMI) will then be calculated and recorded.
- The participant's thigh circumference, limb length, and thigh skinfold will be measured and recorded. Based on these values the researchers will calculate the participant's estimated total thigh muscle cross-sectional area (CSA).
- During Phase 2, the researchers will verbally explain the protocol of the counter movement jump (CMJ) task and the other functional tests that will be administered during Phase 3 of this study (see below) to the participant.
- The researchers will ask that the participant refrain from smoking (or any other tobacco product) and caffeine intake the four hours preceding Phase 3, as well as any heavy resistance training the 48 hours preceding Phase 3.

C. Phase 3:
- During Phase 3, the participant will first perform a brief, five minute warm-up on a bicycle ergometer with a light, self-selected, resistance level.
- The participant's hip range of motion will then be measured with a goniometer (a kind of ruler). This measurement will take place while the participant is lying on their back and raising their leg (with knee completely straight) as far as comfortably possible and holding that position while a goniometer measurement is recorded.
- The participant's hamstring flexibility will be measured through a sit and reach test. This test will require the participant to sit on the ground with their back against the wall, with their legs straight out and feet touching the measurement device (with shoes off). The researchers will then determine the participant's starting position for this test. The participant will then place their dominant hand over their non-dominant hand and lean forward, pushing the meter on the device as far forward as they can without 'bouncing' back and forth.
- During the CMJ task, EMG measures will be recorded. EMG is a non-invasive method to measure the electrical properties of muscle. The hair on 6 places on each of the participant's thighs (3 in front, 2 in back, and one on the outside of the knee), and 1 place on the participant's upper calf will be removed with a brand-new disposable razor (a new razor will be used for each participant). After removal of the hair, the participant's skin will be cleaned with rubbing alcohol. Both legs will be tested. These methods are necessary to make sure the information from the electrodes is clear. If they prefer, the participant can perform the shaving procedure themselves. Once cleaned, 2 electrodes (7/8"x7/8" stickers) will be taped to the cleaned areas on the participant's thigh. Wires from the electrodes are then connected to a device (Noraxon Telemyo 2400T G2) that measures and records the electrical activity of the muscles.
- The participant will then be seated in a comfortable chair with their knees at 90° of flexion. The researchers will conduct manual testing to determine the participant's maximum voluntary contraction (MVC) values for knee extension and knee flexion. This will be done by having the participant push and pull their leg into the researchers' hands as hard as they can. These values will be used to normalize the EMG amplitudes during the CMJ trials.
- Lastly, the participant will be fitted with the Myotest Sport unit and belt. The Myotest unit is a small accelerometer based device that will measure the height, force output, work output, and

velocity of each of the participants CMJ trials. This device is attached to a neoprene belt that the participant will have around their waist.

- The participant will then perform one practice CMJ trial to ensure that the Myotest Sport unit and the EMG amplitudes are being recorded properly. The researchers will also validate that the participant is using correct form during the CMJ.
  - CMJ Instructions:
    - The participant will begin each jump (trial) with their hands on their hips.
    - The participant will listen for the sound of the second beep (stimulus) from the researchers.
    - The participant will squat in a downward motion and propel themselves upward, and jump off the ground as high and as fast as they can, with their hands remaining on their hips.
    - The participant will perform three successful CMJ trials. The researchers will record information from the Myotest and EMG data between each successful trial. A trial will be considered unsuccessful if: the participant starts their movement before the proper stimulus (false start), the participant removes their hands from their hips during the jump, the Myotest Sport unit cannot properly assess the trial, or the EMG data is not properly recorded.
- After three successful trials are recorded, the Myotest Sport unit and EMG electrodes will be removed and the participant's commitment to this study is over.

2) The information gathered in this study will be used only for research and publication purposes. Aggregate data obtained from the participants will be used to investigate the possible differences in power production during the CMJ between extraverts and introverts. Data, in aggregate form, may be presented at scientific meetings and in the scientific literature. In no case will individual participants be identified by name.

SECTION E: Risks to Subjects

Research risk is the probability of harm occurring as a result of participation in research. In non-technical language, address the following:

1) The types of risks (e.g., physical, psychological, social, economic, legal, etc.) the subject may ***reasonably*** encounter.
2) Identify the **frequency/likelihood** of those risks.
3) Describe the **procedures/process** which will reduce or minimize risks:
   a. How the data will be safeguarded (e.g., data is anonymous, assigning pseudonyms, coded, etc.).
   b. Where data will be stored and who will have access to it.
   c. What will happen to the data after the study is complete.
   b. What happens if the participant gets hurt or upset? E.g., referred to Norris Health Center, PI will stop the interview, given telephone hotlines for abuse, etc.

1) It is possible that participants may experience minor musculoskeletal muscle strains, muscle soreness, and/or tightness as they might with any form of physical activity. It is also possible that participants may experience minor skin irritation from the shaving of their skin and/or placement of the EMG electrodes.

2) The potential risks that participants face by participating in this study are minimal and no different from those associated with everyday physical activity and shaving.

3) The small potential for any risks will be reduced further by recruiting participants who are currently active and accustomed to physical activity. Further, all personnel involved in testing are trained in adult cardiopulmonary resuscitation (CPR) and first aid procedures.
   a. An identity key file containing subject names, participant ID code, and contact

information will be stored (in a locked file in the HPSP Lab in PAV 365) separate from all collected data for the purpose of contacting subjects for follow-up testing. All experimental data and associated questionnaires will be stored in a file based on a participant ID code (e.g., EXS1) unique to each participant and separate from any contact information. At no time will the coded data files include names or contact information. All data from the non-participating group participants will be kept, but will not be used in this study.

b. All data will be stored in a locked file in the HPSP Lab in PAV 365. Only the PI (Ebersole), co-PI (Cornell), and approved graduate students will have access to the data for research purposes.

c. The information gathered in this study will be used only for research and publication purposes in the form of aggregate data only. In no case will individual participants be identified by name. Aggregate data obtained from the participants will be used to investigate potential differences in power production during a CMJ between introverts and extraverts. Data, in aggregate form, may be presented at scientific meetings and in the scientific literature.

d. The testing sessions will be terminated in the event that the subject indicates any discomfort such as leg pain or cramping or other sign and symptom that could be associated with a medical condition. The testing will also be terminated if requested by the participant. In the event that a testing session is terminated for a possible medical reason, laboratory personnel will manage the situation per the standard first aid guidelines and procedures of the American Red Cross and refer to Norris Health Center or contact the Emergency Medical System.

SECTION F: Benefits and Compensation

1) **Describe any direct benefits** participants could potentially receive**.** If there are no direct benefits, explain.
2) **Explain how the risks compare to benefits.**
3) **If monetary or gift compensation will be given to subjects, explain:**
   d. In what form (i.e., cash, check, pens, etc.,).
   e. The amount or approximate value.
   f. When the participant will receive the item (e.g., $5 after completing each survey, subject will receive [item] even if they do not complete the procedure).
4) **If extra credit will be offered, explain:**
   a. If an alternative task that is not study related will be offered for the same extra credit.
   b. If the task is a class requirement/assignment that students would be required to complete even if the study was not being conducted.

1) Participants will not receive any particular direct benefits from this study.

2) We believe that the risk-to-benefit ratio for this study is quite low. The risks involved in this study are very minimal in comparison to what the participants are exposed to in the daily routines of life and exercise, or completing any other survey or questionnaire. The benefits from this study will aid in the understanding of psychophysiological differences between introvert and extravert personality groups.

3) No monetary compensation will be given to participants.

4) This study will be associated with extra credit in some undergraduate Dept. of Kinesiology courses (HMS 400 & HMS 270). Participation in this study is not a requirement of the students in any way. If the student choses to not participate in this study, or does not meet the inclusion criteria for this study, other extra credit opportunities will be available to them.

SECTION G: Deception/ Incomplete Disclosure (INSERT "NA" IF NOT APPLICABLE)
If you cannot adequately state the true purpose of the study to the subject in the informed consent, deception/ incomplete disclosure is involved. **1)** Describe the deception/ incomplete disclosure of information to the subjects. **2)** Explain why such deception/ incomplete disclosure is necessary. **3)** Explain the debriefing process, or explain why there will not be a debriefing process.
1) N/A 2) N/A 3) N/A

SECTION H: Conflicts of Interest
When researchers are involved with commercial ventures, there is the potential for diverting from their primary mission of research and education. Conflicts of interest can arise when the interests of the commercial venture differ from the interests and primary obligations of the researcher, or when the commercial venture consumes an undue share of employee time. Contact the Graduate School Research Services and Administration for more information.

Reminders:

1. Make sure all questions that are applicable have been answered on this form.
2. Responses should be consistent with other forms (e.g., New Study Submission Form, Consent Form, etc.).

APPENDIX H

Example Data Sheet

Human Performance & Sport Physiology Lab
Department of Kinesiology
University of Wisconsin – Milwaukee
3409 N. Downer Ave
Pavilion – Physical Therapy, Room 365
Milwaukee, WI 53211

ID #: ________________

Counter movement jump performance differences between introverts and extraverts – David Cornell Thesis

Date: ______________ E Score / Group: _______/_____________

N Score:_______ Age: ______ Date of Birth: _____________

Height (cm): _______ Weight (kg): _______ BMI: _______

Ham Flex Right (°): ________ Ham Flex Left (°): _________

Circum Thigh Right (cm): __________ Limb Length Right (cm): __________

Circum Thigh Left (cm): __________ Limb Length Left (cm): __________

SF Thigh Right (mm): _________ Est Total Thigh CSA Right (cm^2): ___________

SF Thigh Left (mm): __________ Est Total Thigh CSA Left (cm^2): ____________

Sit & Reach (cm): _______ Dominant Stance Leg: ______________

Counter Movement Jump Trials - Myotest				
	1	**2**	**3**	**AVG**
Height (cm)				
Power (W/kg)				
Force (N/kg)				
Velocity (cm/sec)				