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Performance correlates of mental toughness among female
Thai boxers

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Abstract

Background The increasing interest over the past few years in legal performance enhancement in sports lead to a multitude of researches focusing on psychological and physical factors influencing performance and success rate. Of particular interest is mental toughness, a construct explaining mental strength in competition.

Purpose This is a cross-sectional study comparing several variables between three groups of female Thai boxing competitors. Main focus lies on the role of mental toughness and other sports related constructs such as digit ratio (2D:4D), aggression, sex role identity, handgrip strength, laterality and maximum punching power towards achievement level.

Method A questionnaire, an indirect (computer-based) measurement procedure to assess aggression (Implicit Association Test: IAT- Aggression), a handgrip strength dynamometer, a computer-based instrument SCHLAGMESSER and hand scans were performed to acquire data from 87 female Thai boxers. All participants were competitors, divided into groups Newcomer (> 4 fights), Amateur (4 to 10 fights) and Professional (11 or more fights). Instruments used to assess mental toughness were MTQ48, SMTQ and TROSCI, instruments used to assess aggression were BPAQ- Physical Aggression and IAT- Aggression.

Results Mental toughness and other measured psychological constructs had no significant predictive value towards performance and success rate in Thai boxing. Significant predictors were fighting experience, maximum punching power of the back hand and knockout rate. Professionals showed significantly less physical aggression than Amateurs and Newcomers. Fair to strong correlations between handgrip strength, maximum punching power and flexed biceps circumference were found.

Conclusion The findings imply the need for a different mental toughness construct for Thai boxing or full contact combat sports in general compared to other sports. The only valid predictors towards success were fighting experience, maximum punching power of the back hand and the knockout rate, indicating good physical conditioning.

Introduction

“Champions keep playing until they get it right.” (Billie Jean King, n.d.)

Dedication, talent, an extraordinary physique or relentless striving to be the best; what does it take to be a champion? The physical, technical and mental requirements to achieve top performance rise constantly. There is no room for mistakes at the top, the line between being an average athlete and a champion is razor-thin. Keeping a cool head, staying focused under pressure even in the most unpromising of conditions could make the difference between winning and losing. In search of the key to success scientists found that successful athletes seem to have mental toughness (MT), a certain variety of psychological strategies to deal with challenging situations (Moesch, 2008). Discovering those certain psychological strategies lead to the question whether the reason some people have them and some don't lies in disposition or the environment, nature or nurture.

“We are what we repeatedly do. Excellence, then, is not an act, but a habit” (Aristotle, n.d.). As important as the right physical condition is the right mindset, and, according to Spielberger (2011), such as training a muscle the mind needs to be trained continuously as well. Athletes, coaches and scientists all over the world keep chasing after the newest, legal performance enhancer, therefore seeing traits as self-confidence, faith in oneself and one's abilities, dealing with extraordinary pressure and regaining control after unforeseen events as labile would leave room for improvement and could make the crucial difference. The results of Horsburgh, Schermer, Verselka and Vermon (2008) suggest that the environmental influence on MT is crucial and psychological strategies can be trained. The assumption that these traits are considered labile raised interest in measuring and

enhancing them. But how is one supposed to measure MT? As an often used but rarely understood term, sports psychologists gained interest in defining MT not only qualitatively but also quantitatively (Crust & Swann, 2009).

This thesis discusses the postulated difference between successful and mediocre athletes in MT as well as other psychological and physical dimensions in relation to Thai boxing.

Theoretical Background

1.1 Thai boxing – Muay Thai

1.1.1. History

Muay Thai, the combat sport as we know it today, evolved from Muay Boran, an ancient, unarmed combat method which Siamese soldiers would use in battle in case of losing their weapons.

In 1767 the kingdom of Ayutthaya was brought down by invading Burmese armies, burning down the city of Ayutthaya and destroying the archives of Thai history. Every written source about the origins of Muay Boran had been destroyed. The little sources left were writings of the Burmese, Cambodian and early European visitors. The first Thai army is believed to have been created in 1238, the beginning of the Sukhothai era, as a consequence of the secession of Sukhothai kingdom from the Khmer empire. With the constant threat of war, young men were trained at training centers in Muay Boran and Krabi Krabong, a weapon based combat method. At first only required for poor and common people, Muay Boran soon became an obligatory part in the education for the high-class and royalty.

The change of interest in Muay Boran as a sport first appeared in 1584 under King Naresuan, who practiced the combat form himself. From that time on, Muay Thai was not only used as a way of self-defense but also in regulated matches, although the most radical changes did not appear before the early twentieth century. In 1920, Muay Thai was withdrawn from the school curriculum because of the high injury rate. The first permanent Muay Thai Arena and also the first boxing ring were built in 1921 at Suan Kularp (Rose Garden) in Bangkok. In the late 1920s boxing gloves were introduced to fighters, along with today's rules and regulations.

Interest in Muay Thai began flourishing around the world in the 1970s in conclusion to the movies of Kung Fu practitioner Bruce Lee.

1.1.2. Thai boxing in Europe

In the 1970s Muay Thai and Japanese Kickboxing (K1) were first introduced in the Netherlands by Jan Plas and Thom Harinck, the founders of the NKBB (Dutch Kickboxing Association). The typical Muay Thai style got modified by Western European combat sports, even though the most substantial changes were influenced by Western boxing.

1.1.3. Women in Muay Thai

Traditionally, women were excluded in partaking at Muay Thai contests due to strong Buddhist beliefs. Superstition and the belief in evil spirits and ghosts were the main reason to consecrate every ring. In order to achieve well-meaning, a monk would undertake several ceremonies and pray to these spirits. According to this Buddhist belief, women represent desire and therefore may not be touched by a monk or enter a ring, otherwise the spirits may end up being hostile towards every fighter entering the ring.

Along with the gender movements of the 1960s and 1970s women in Thailand found interest in the sport of Muay Thai and slowly started to participate in competitions. Even though women are still restricted from competing at certain stadiums in Thailand and have to enter a ring below the ring ropes, the interest in female fights around the world continuously increases.

1.1.4. Techniques

Because of its techniques Muay Thai is also called “The Art of Eight Limbs”. Allowed are punching, elbow strikes, kicking and knee techniques to the legs, body or head.

Also, setting itself apart from Western boxing, clinching and neck wrestling are legitimate techniques in Thai boxing.

1.1.4.1. Punching

Similar to Western boxing, the punching techniques include straight punches such as the jab and the cross, hooks and uppercuts. In addition to that the spinning backfist, which is performed by forming a fist and turning 360°, landing the punch with the back of the hand, is a legitimate technique. Punches can be used to the head or the body, even though body punches are used less to avoid exposing the attacker's head to kicks and knee strikes.

1.1.4.2. Elbow strikes

The elbow is used to either finish the fight via knockout or to cut the opponent's skin, so the blood might block the opponent's vision. Elbow strikes can be executed horizontal, diagonal-upwards, diagonal-downwards, uppercut, downwards, backward-spinning and flying. Elbows need to be performed in very close distance therefore they are often utilized during the clinch.

1.1.4.3. Kicking

Even though there is a great variety of different kicking techniques, including spinning kicks, heel kicks and flying kicks, the two most commonly used are the front kick, also known as theep, and the roundhouse kick. The front kick is a foot thrust used mainly to control distance or block attacks. The roundhouse kick is a kick to the opponent's side, including the rotation of the attacker's standing leg and his hips. Kicks are executed with the shin to avoid hurting the fine bones in the much weaker foot. Targets are the legs, body or head. To check a technique, the fighter will block the kick with his own shin or catch the attacker's leg and counterstrike.

1.1.4.4. Knee strikes

A knee strike is a very powerful technique, used either to the body or the head, applied from separated or clinching position. Knees can be executed straight, diagonal, curving, horizontal and flying. Khao loi, which means small knee, describes a knee strike to the opponent's thigh, often used during the clinch.

1.1.4.5. Clinching and throws

Clinching and neck wrestling describes the positioning and holds of fighters engaged in stand up grappling. Fighters will try to achieve a dominant position by grabbing the opponents head and pulling it down. During the clinch the fighter will try to execute knee and elbow strikes or throw the opponent. Throwing techniques are limited as of Judo and Wrestling techniques are considered illegal.

1.1.4.6. Fouls

Biting, eye pocking, spitting on the opponent, head butting, continuing to harm a grounded opponent as well as techniques to the groin, the back of the head or the spine are considered illegal. The fighters have to obey the referee's command at all times.

If a fighter accidentally fouls his opponent he will be given either caution or a warning, fouling on purpose can lead to instant disqualification.

1.1.5. Rules and Regulations

1.1.5.1 Weight divisions

Such as in Western boxing, Thai boxing fighters compete in a certain weight category. There is a great diversity in a division's range and weight limits depending on the association

in charge. All associations have the lowest weight division at 105 lbs or 47.62 kg in common, as well as a fighter's minimum weight of 100 lbs. Also, the time of the weigh in is determined by the event's organizer, varying between 24 hours up to 3 hours before the fight.

1.1.5.2. Equipment

Amateur fighters are obliged to wear hand bandages, gloves, headgear, shin guards, elbow pads, a mouthpiece, groin protection and, for female fighters, breast protection. Professional fighters may not wear anything but bandages or tape on the hands, gloves, a mouthpiece, groin protection and, optionally, breast protection.

All fighters are obliged to wear shorts no longer than to the knee, with the addition of a tight, sleeveless sports top for female fighters.

Female fighters are also obliged to neatly tie their hair without tangling ends, hair bands may not contain metal or hard plastic.

1.1.5.3. Rounds

The bout originally consists of five rounds of three minutes each, with a resting interval of two minutes between each round. Around the world the number and duration of rounds vary between two rounds of two minutes each minimum and the original number and duration of rounds maximum. The most common type of bouts in western countries is three rounds of two minutes each with a one minute break for amateurs and three rounds of three minutes each with a resting interval of one minute for professionals.

1.1.5.4. Scoring System, Judges and Referee

A minimum of three judges, sitting at three sides of the ring, score the fight independently and according to the association's rules and scoring system. The most commonly used scoring system is the 10:9 system. Full ten points are given to the winner of

the round, whereas the opponent gets nine or less points. Every round must be scored right away, each round's score will be added to the final score at the end of the fight.

A fighter scores using fists, legs, knees and elbows as muay thai fighting weapons to hit his opponent powerfully, accurately, unprotected and according to the rules. Each technique scores equally, as long as it is executed within the rules and with the intention to end the fight.

The primary concern of the referee should be the fighters' wellbeing. Some of the most important duties are to prevent a weaker boxer from receiving undue and unnecessary punishment, to control that the rules and fair play are observed at all times, controlling the start, break and end of a fight, counting to eight in case of a knockdown and terminating the contest at any time in case of one fighter's inability to protect himself.

1.1.5.5. Decisions

A fight can result in winning by points, knockout, technical knockout (TKO) and disqualification, in case both fighters scored the same the fight will result in a draw. For a win by points, either a majority or a unanimous decision at the end of the bout is necessary. In case a fighter is being knocked down and cannot continue to fight, his opponent wins by knockout. A technical knockout includes the referee's decision to stop a fight and or if a fighter chooses to forfeit.

1.2. Mental Toughness

Long before there was a scientific interest in the construct of MT, coaches and athletes used the term to describe the qualities of a champion. Experiencing a great amount of stress during competition, some athletes would break under the pressure and would not be

able to perform up to their talents. They were not tough enough. In the early 1980s, the sports psychologist James Loehr emphasized the necessity to define and measure MT, for as athletes and coaches felt that at least fifty percent of success is due to psychological factors (Loehr, 1982, 1986; as cited in Middleton et al., 2003). Also behavioral studies indicated a considerable influence of personality traits towards success, athletes seemed more “tough-minded” than the rest of the population (Eysenck, Nias, & Cox, 1982).

1.2.1 Definition

Even though the term “tough-minded” was often used, first attempts to define MT concluded in inadequately phrased, little specific definitions without scientific evidence. In his early work, Loehr (1986) claimed that mentally tough athletes respond to pressure by remaining calm, relaxed and energized. He postulated seven attributes of MT, which further researchers found to be empirically unsubstantiated. The first empirically oriented qualitative studies to analyze the term mental toughness were implemented by Fourie and Potgieter (2001) and Jones, Hanton and Connaughton (2002). In both studies researchers found MT to be a multi-dimensional construct and both identified twelve components. Jones et al. (2002, p. 209) suggested following definition of MT:

Mental toughness is having the natural or developed psychological edge that enables you to:

- *Generally, cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; and,*
- *Specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure.*

This definition implies that mentally tough athletes are generally able to remain focused and controlled and keep pursuing their goals, even in high pressure situations.

Middleton, Marsh, Martin, Riches and Perry (2004a) criticized Jones et al.'s tendency to confuse what MT allows one to do rather than to describe what MT is. After further research, they suggested their own definition of MT, which requires the presence of some or all of the twelve MT components:

“Mental toughness is defined as an unshakeable perseverance and conviction towards some goal despite pressure or adversity.” (p. 6)

Furthermore, the authors understood MT not only as a multi-dimensional but also as a hierarchical construct. They divided the twelve components within two main categories, toughness-orientation, which includes factors that are personal characteristics, and toughness strategies, which include factors that are actions.

Based on Kobasa's (1979) hardiness theory, Clough, Earl and Sewell (2002) developed a different definition of MT. From this approach mental toughness is being looked at as characteristics individuals possess, a trait-like construct, which consists of four dimensions and is known as the 4 C's model. Often described as the key factors of MT (Crust, 2008; Jones et al., 2007; Sheard, 2010), the 4 C's are:

- **Control** describes a person's tendency to feel in control of one's environment and to act accordingly. This factor refers to emotional control and control of life itself.
- **Challenge** describes a person's tendency to interpret problems as an opportunity for personal growth.
- **Commitment** describes a person's ability to successfully continue achieving certain goals despite obstacles that may occur along the way.

- **Confidence** describes the extent to which a person's self-belief remains unshakeable while completing difficult tasks. This factor refers to confidence in one's abilities and confidence in one-self.

According to AQR (2011, para 1.), mental toughness is *“the capacity for an individual to deal effectively with stressors, pressures and challenges and perform to the best of their abilities irrespective of the circumstances in which they find themselves”*. Mentally tough people are therefore considered to be calm, relaxed, rarely anxious and with strong belief in themselves. Resulting from these traits, people with distinctive MT enjoy interpersonal comparison and are more likely to seek competition.

Even though there appears to be a certain consensus about which abilities a mentally tough person possesses (Jones et al., 2002), the question whether there is one construct of MT, applicable for every situation and sport, or different forms of MT (Bull, Shambrook, James, & Brooks, 2005) is yet to be answered.

1.2.2. Developing Mental Toughness

As in many other scientific fields, the question of nature vs. nurture is of great importance. The extent to which MT can be influenced by environmental circumstances plays a crucial role in psychological research and applied sport psychology. Many researchers find MT to show partially stable characteristics. Jones et al. (2002) assume that some traits are both inherited and influenced by the environment, whereas Clough, Earle and Sewell (2002) propose that the tendency to remain unaffected by competitive events is disposition. The correlations between MT and a higher tolerance towards pain, a better overall performance (Crust & Clough, 2005) and faster rehabilitation after an occurring injury (Levy, Polman, Clough, Marchant, & Earle, 2006) also indicate trait-like attributes.

On the other hand, Bull et al. (2005) found a fluctuation in MT scores over time, supporting the assumption of MT as a flexible construct. In a study of Jones et al. (2007) successful athletes claimed a natural disposition of MT, developing over time and growing with experience. Gucciardi, Gordon and Dimmock (2009) were able to significantly enhance MT in youth soccer players using psychological skill training.

MT could therefore be interpreted as a construct influenced, but not fully explained by personality traits.

Looking at MT as a partially stable construct consisting of dispositions, e.g. coping style, optimism, etc., and personality traits, e.g. neuroticism, dominance, etc., Lazarus and Folkman (1984) claim that unlike personality traits, dispositions are situational and highly susceptible for intervention.

Bull et al. (2005) suggest a long-term development of MT, in which environmental influences appear to be the foundation to three levels of MT attributes: tough character, tough attitude and tough thinking. A tough character being the engine in the hierarchical model includes personality traits relevant for MT. These traits are considered stable. A tough attitude serves as fuel in the authors' model and describes habitual patterns, which are situational and teachable. At the top of the hierarchy there is tough thinking, which describes desirable mental strategies used directly during a competition.

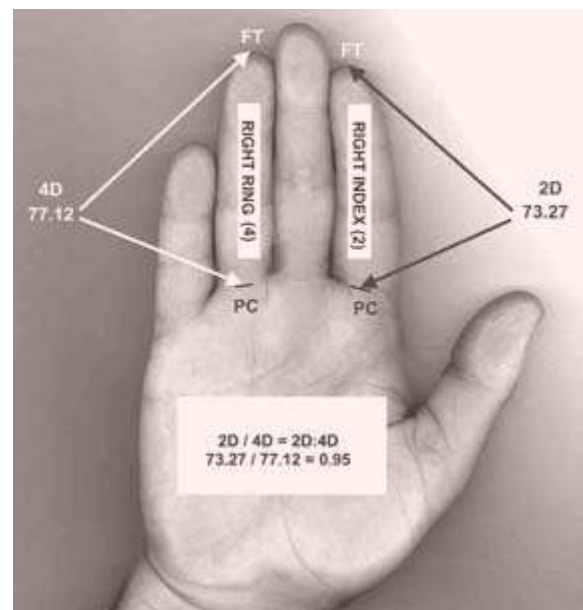
1.2.3. Mental toughness in relation to success in sports

As previously mentioned, it is yet to be discovered whether there is one construct of MT, applicable for every individual, sport and situation, or several forms of MT (Bull et al., 2005). Gucciardi et al. (2009) found evidence that strong performing athletes scored higher at MT questionnaires. In an extensive study including 677 participants, Nicholls, Polman, Levy

und Backhouse (2009) could not demonstrate the expected differences in MT between beginners and University athletes. Based on these controversial results it is important to keep in mind that MT might correlate with a strong performance but is only one out of many factors responsible for success. Physical talent, technical skills and time invested into training play a crucial role in an athlete's performance (Crust & Azadi, 2010; Gerber, 2011; Nicholls et al., 2009). Concerning the psychological component, moderating factors might also play a role. Even though a correlation between MT and a strong performance was established (Gucciardi et al., 2009), the results regarding MT and success in sports turned out to be little conclusive (Crust & Azadi, 2010; Nicholls et al., 2009). Moderating factors could be differences in coping strategies, in the perception of stress levels and the intensity of perceived emotion.

1.3. 2D:4D

2D:4D is an acronym for second digit to fourth digit (Manning, Scutt, Wilson, & Lewis-Jones, 1998) and describes the proportion of length between index finger (2nd digit) and ring finger (4th digit). The digit ratio quotient is determined by dividing the length of second finger by the length of the fourth. Early researchers focused on a comparison between male and female digit ratio and found it to be gender-dimorphic (Manning et al., 1998; Phelps, 1952), for male participants showed lower digit ratios



Ill.

1

2D:4D-Verhältnis

[http://www.handresearch.com/news/Menu_bestanden/digit-ratio-method.jpg]

than female participants. Differences in digit ratio were found to be substantially heritable

(Voracek & Dressler, 2007) and appear to develop prenatally (Galis, Ten Broech, Van Dongen, & Wijnaendts, 2010). Between 1998 and 2011, about 450 studies analyzing the effects of 2D:4D were published (Voracek, 2011), trying to relate prenatal androgenic influences to the human brain, body and behavior.

1.3.1. Prenatal testosterone levels in relation to 2D:4D

The observation of differences in finger length between men and women can be traced back more than hundred years ago. Ecker (1875, as cited in Reimer, 2009, p. 5) was the first scientist to mention these differences, even though the first scientific evidence, connecting prenatal testosterone levels and digit ratio, was found by Manning et al. (1998). The authors' findings indicate a correlation between high intrauterine testosterone levels and a low digit ratio, explaining an occurring average digit ratio quotient < 1 in males and > 1 in females. Testosterone was found to stimulate the growth of the ring finger, whereas estrogen was found to stimulate the index finger's growth (Manning, 2002a). Biologically responsible are the homeobox- or hox-genes, which also control the development of the gonads (Herault, Fraudeau, Zákány, & Duboule, 1997; Voracek & Manning, 2003). Individual and sex differences in digit ratio start to develop within the seventh gestational week (Phelps, 1952; as cited in Manning, 2002a) and are considered stable over time, as the individual ratio stays the same over puberty and adulthood (Fink, Neave, Laughton, & Manning, 2006). This observation made the digit ratio eligible as a biomarker to objectify effects of masculinity through prenatal testosterone for scientific research (Manning et al., 1998).

1.3.2. 2D:4D ratio in sports

Competitiveness, speed, endurance, strength and a good visual-spatial judgment are important abilities high-class athletes must possess. Manning and Taylor (2001a) found all

these abilities correlating with a low digit ratio. Also, both male and female athletes with low digit ratio were found to be higher involved in competitive sport, showing more frequent training attendance (Manning, Morris, & Caswell, 2007).

1.3.3. Relevance of 2D:4D ratio for female athletes

Regarding the fact that digit ratio is a biomarker for prenatal testosterone influence, one could assume that in spite of inter-individual differences of digit ratio the effect might not be significant enough for female athletes due to generally higher intrauterine estrogen levels. However, former research found female athletes to show higher competitiveness and aggression than non-athletes (Cooper, 1969; Lenzi et al, 1997; as cited in Pokrywka, Rachoo, Sucheka-Rachoo, & Bitel, 2005), making the assumption of a negative correlation with digit ratio very plausible. Pokrywka et al. (2005) found evidence to support the idea of digit ratio as a correlate of sports potential for female athletes. In their study, the digit ratio of 138 females, non-elite athletes and elite athletes, was measured and compared with female individuals who were not practicing any sport. The authors' result showed a significantly lower 2D:4D digit ratio of the left hand in elite athletes than the non-practicing control group. However, differences between elite and non-elite athletes were too small to reach significance. Hönekopp, Manning and Müller (2006a) measured 2D:4D of 77 young females, finding also only the left hand's digit ratio to correlate negatively with physical fitness. Bescos, Esteve, Porta, Mateu, Irurtia, and Voracek (2009) found a significant effect of prenatal exposure on success in sports in 87 female world-class fencers, even though a correlation only appeared for the right 2D:4D ratio. Remarkable is the fact that this effect was found in a homogeneous group of already world-class athletes, leaving possibilities to predict sporting ability through digit ratio open. Voracek, Reimer and Dressler (2009) found within their sample of 44 female Austrian fencers a low digit ratio to correlate with better national

rankings, even after controlling salient performance factors such as age, years of training experience and training intensity.

1.4. Aggression

The Oxford dictionary defines aggression as “*feelings of anger or antipathy resulting in hostile or violent behaviour; readiness to attack or confront*” (Oxford University Press, 2013). Buss and Perry (1992) found aggression to consist of four dimensions, physical aggression, verbal aggression, anger and hostility. The issue of aggression in sports is often discussed and of great importance. Scientists, coaches and athletes agree that assertive behavior is necessary to achieve certain goals in sports, but at the same time urge to distance athletes from the image of the drunken, aggressive athlete. Researchers have not yet agreed on whether sports, in particular contact sports, facilitate hostile behavior or serve as an accepted way to release hostile emotions (Lemieux, McKelvie, & Stout, 2002). Social learning theory (Bandura, 1973) suggests that aggressive behavior can be learned by observation and imitation of others or even oneself, leading to a circular repetition. The fact that aggressive behavior in contact sports is often rewarded makes the occurrence in different situations more likely.

An opposing theory is the catharsis theory (Bushman, Baumeister, & Stack, 1999), according to which sporting activity serves as a healthy way to release aggression, a basic instinctive drive, and therefore decreases aggressive behavior. Lemieux et al. (2002) investigated the differences in aggression between contact and no contact athletes, including a control group of non-athletes, using the Buss and Perry’s (1992) Aggression Questionnaire (BPAQ). The results were inconclusive, showing higher scores on the Aggression Questionnaire for contact athletes than for no contact athletes, but also for the matched

control group, indicating no differences between athletes and non-athletes and contradicting both learning and catharsis theories.

The unsettled question whether aggression plays a considerable role in contact sports leaves room to speculate the function of aggression in combat sports, which will be discussed in this study.

1.5. Hypotheses

Particular attention of this study's hypotheses will be turned to MT and its correlates. Next to MT, digit ratio, aggression, laterality and punching power will be taken into special consideration. Digit ratio, aggression and laterality are current subjects of sport psychology and will be analyzed based on previous studies, punching power will be explored as a new physical component and possible altering factor for success in Thai boxing. Eventually this study will serve to investigate the importance of MT, digit ratio and several other variables influencing success in Thai boxing, possibly allowing future predictions.

1.5.1. Hypotheses concerning Mental Toughness

Based on controversial findings concerning MT and performance level in different sports (Gucciardi et al., 2009; Nicholls et al., 2009), the question of the effects of MT on sporting achievements will be of high importance in this study. MT will be measured by using the MTQ48 (Clough et al., 2002) and the SMTQ (Sports Mental Toughness Questionnaire; Sheard, Golby, & van Wersch, 2009). Both questionnaires claim to measure the same construct of MT hence a strong positive correlation is expected.

Different psychological factors associated with MT could alternate results and will be taken into consideration. Beattie, Hardy, Savage, Woodman and Callow (2011) claimed a

strong correlation between MT and self-confidence, therefore a positive correlation between the MTQs and the TROSCI (Trait Robustness of Self-Confidence Inventory; Beattie et al., 2011) is expected. The willingness to accept high physical risks (Crust & Keegan, 2010) suggests a positive correlation between MT and aggression. Given the fact that Thai boxing is a full contact combat sport and requests a high willingness to accept physical risks, higher MT scores for this study's participants are expected in comparison to other female athletes.

In addition to that, a possible correlation between MT and digit ratio will be explored. Both MT (Gucciardi et al., 2009) and digit ratio (Voracek et al., 2009) were already associated with sporting performance and are therefore expected to be negatively correlated.

1.5.2. Hypotheses concerning digit ratio (2D:4D)

A low prenatal testosterone level and therefore a low digit ratio have been associated with achievement levels in several different sports (Manning & Taylor, 2001; Manning, Bundred, & Taylor, 2003). These findings proved to be consistent also for female athletes (Voracek et al., 2009), leading to the assumption that digit ratio can be expected a predictor of performance level in this study.

A meta-analysis by Voracek et al. (2011) showed no evidence to support correlations between digit ratio and sex role identity. This study will investigate the relation between sex role identity and digit ratio.

Digit ratio was found to highly correlate with handgrip strength (HGS) in males but not in females (van Anders, 2007; Gallup, White, & Gallup, 2007). Even though a significant correlation in this study seems implausible the relationship between 2D:4D and HGS will be analyzed.

1.5.3. Hypothesis concerning laterality

Many researchers found left-handedness to be an advantage in several different sports (Dufour & Moller, 1996; Grouios, Tsorbatzoudis, Alexandris, & Barkoukis, 2000; Holtzen, 2000; Raymond, Pontier, Dufour, & Moller, 1996), and also found it to be highly represented in competitive manual sports (Annett, 1985; Azémar, Ripoll, Simonet, & Stein, 1983; McLean & Ciurczak, 1982; Raymond et al., 1996; Voracek, Reimer, Ertl, & Dressler, 2006). The most famous southpaw (an official term used in combat sports to describe a fighter's reversed stance) in boxing, Muhammad Ali, left scientists wondering whether the different stance proves itself beneficial in general. Gursoy (2009) found a significant difference in success rates between left- and right-handed boxers, favoring southpaws. Regarding the fact that Thai boxers need to master both arms and legs as active weapons, it is questionable whether previous findings can be adopted for this study's combat sport. Common belief is that southpaws are tougher opponents due to their rareness, so left-handed fighters are expected to be more successful in Thai boxing.

1.5.4. Hypotheses concerning Aggression

Contact sports, especially full contact combat sports, seem to attract people who are naturally more aggressive than the majority (Lemieux et al., 2002). Crust and Keegan (2010) found a positive correlation between MT and physical risk-taking, so it is of great interest whether athletes practicing Thai boxing are naturally more aggressive than controls. Previous research almost exclusively found females to avoid physical aggression and choose a different form of aggressive behavior (Hess & Hagen, 2006). On this account participants of this study will be compared to the normal population regarding physical aggression using the physical aggression scale of the BPAQ (Buss & Perry, 1992). In addition to that the Implicit

Association Test (IAT: Greenwald, McGhee, & Schwartz, 1998) will be used to avoid socially desirable responses and get an insight in spontaneous affective (i.e. automatic) attitudes towards aggression. Common belief suggests that aggression might interfere negatively with success in Thai boxing, even though it seems plausible that a certain amount and kind of aggressive behavior is necessary and will be rewarded with a win. This study will investigate aggression's role towards success in Thai boxing.

By comparing aggression means between groups *Newcomer*, *Amateur* and *Professional* and correlating years of practice with both aggression instruments, a step towards analyzing possible learning effects through participation in full contact combat sports will be attempted.

Ballerstein (2011) found a positive correlation between BPAQ- Physical Aggression and IAT- Aggression, implying that a higher directly measured aggression indicates a higher implicitly measured aggression. IAT scores range from - 2 to + 2, whereat low scores imply high aggression. For better understanding score values were reversed in this study, whereby high IAT scores mean high aggression. Since both instruments claim to measure the same construct, a positive correlation is expected.

1.5.5. Hypotheses concerning Handgrip Strength

Handgrip strength proved to be a considerable indicator for physical health, blood testosterone levels, lean body mass and aggressive behavior (Gallup et al., 2007), even though results were found significant only for males but not females. However, previous research focused mainly on non-athletes, suggesting a possible difference in results for female athletes. On this account this study will investigate the relation between HGS and aggression.

Indicating training status for upper limbs, HGS is expected to correlate with punching power, flexed biceps circumference (Puts, Apicella, & Cárdenas, 2011), and training intensity.

1.5.6. Hypotheses concerning Punching Power

Punching power has not yet been analyzed in psychological research as an alternating factor on success in martial arts. Common sense leads to believe that punching power must have a substantial role in the outcome of a fight, acting as a factor of intimidation and ending fights through knockout. Maximum punching power will be measured with the computer-based instrument SCHLAGMESSER Basic (see Illustration 2; <http://www.schlagmesser.de/index.php/de/produkte/schlagmesser-basic>).

Punching power is expected to have a significant influence on success and the knockout rate.

As for peak punching power, physical condition is of great importance, therefore a positive correlation between HGS, flexed biceps circumference, weight and training intensity is expected.

III. 2 SCHLAGMESSER Basic [https://fbcdn-sphotos-h-a.akamaihd.net/hphotos-ak-ash4/424682_362031510547824_358513865_n.jp]



Method

2.1. Design

This study is a cross-sectional study including 87 female Thai boxing/K1 fighters out of Austria, Germany, the Netherlands and Switzerland. All participants included had experienced at least one fight up to the point of evaluation.

2.2. Procedure

Participants were exclusively found via Facebook. Close to 110 fighters were asked in total, about 100 answered and 87 ended up participating in the study. Approximately 8000km of distance, 27 cities in four countries (Germany: Trier, Vossenack, Aachen, Rommerskirchen, Wuppertal, Ratingen, Duisburg, Essen, Bottrop, Gelsenkirchen, Bochum, Dortmund, Lemgo, Bremen, Hannover, Hamburg, Berlin, Mannheim, Heidelberg, Singen and Munich. The Netherlands: Heerlen, Alkmaar and Rotterdam. Austria: Vienna and Salzburg. Switzerland: Zurich) and 46 different gyms were covered by this study's author. The majority of the fighters were in weight-classes between 51 kg and 65 kg, consistent with general promotion of these particular weight categories. Ranking lists were not considered in this study given the multitude of organizations in Thai boxing. Physical tests, which included the testing of punching power and HGS, were run before practice due to rapid loss of maximum power. The questionnaires, digit ratio and IAT- Aggression were executed in said order after physical tests. In most cases no more than two participants were tested at one appointment, only four training venues hosted several fighters. In these cases group testing was required. Data were collected in March 2012. All participants received information about the study's procedure before completion and voluntarily partook in the process. Approximate testing duration was 45 minutes, proportionally longer for group testing. Paperwork included a declaration of consent, a demographic survey, the Sport Performance Questionnaire

(Manning & Taylor, 2001; multi-stage sport performance scale, only 7 out of 10 steps were presented), the Mental Toughness Questionnaire MTQ48 (Clough et al., 2002), the Sports Mental Toughness Questionnaire SMTQ (Sheard et al., 2009), Buss and Perry's Aggression Questionnaire BPAQ Subscale Physical Aggression (1992), the Trait Robustness of Self-Confidence Inventory TROSCI (Beatie et al., 2011), the Sex Role Identity Scale SRIS (Storms, 1979) and the subscales hand and foot preference of the Coren Lateral Preference Inventory (Coren, 1993) in said order. The demographic survey acquired data about age, height, weight category for a fight, nationality, fighting record, fighting stance, years of practice, training intensity (hours per week), practice of other combat sports and won titles. In case of ambiguity the test administrator was close by to answer questions. Implicit aggression scores were acquired through the computer-based Implicit Association Test IAT (Greenwald et al., 1998) Aggression. Maximum punching power was measured with the computer-based instrument SCHLAGMESSER Basic, after a warm-up period of no more than five minutes to avoid inequity in performance. Each fighter was granted three punches for each side. Handgrip strength was measured with a handgrip dynamometer (Bremshey EH101), twice on each side. Hands were scanned with the HP photo smart 5510 scanner (gray scale, 300dpi). Actual weight was measured with the digital scale TCM 261038. Biceps circumference was measured with a common measuring tape. A closer description of the testing instruments will be presented in the chapter Instruments. After completing paperwork and other tests every participant was given thanks to.

2.2.1. Description of the sample

This study's sample consisted of 87 female athletes practicing Thai boxing/K1 with competition experience. Performance level was mostly amateurs given the fact that Thai boxing is a relatively young and unknown sport in Europe and only a small number of

athletes continue fighting regardless little beneficial circumstances. The participant's ages lied between 13 and 51 years ($M = 25.8$, $SD = 6.67$). Average height was 166.9 cm ($SD = 6.28$) and average competition weight 59.6 kg ($SD = 7.41$). Competition experience level lied between 1 and 66 fights ($M = 10.94$, $SD = 12.87$), with 36.7% competing at state level, 22.9% on national level and 35.6% on an international level. Average training duration was between 0.5 and 20 years ($M = 4.0$, $SD = 3.17$). Average hours spent for training per week were 7.95 hr ($SD = 3.28$), with a minimum of 3 hr and a maximum of 20 hr. Participants lived in Austria, Germany, the Netherlands and Switzerland. 11.5% had a migration background, 59.8% were German, 14.9% Dutch, 10.3% Austrian and 3.4% Swiss. 49.6% of all participants actively practiced or formerly practiced a different combat sport, of which 18.4% was boxing and 23% light- or full contact kickboxing. 86.2% had an orthodox stance, using the left hand/leg as lead hand/leg, 5.7% were southpaws, using the right hand/leg as lead hand/leg and 8% were able to fight in both stances. In combat sports, the term southpaw is the official term to describe a reversed stance. All southpaws and fighters using both stances were left handed or used both hands equally, all fighters using orthodox stance were right handed.

2.3. Instrumentation

2.3.1. Mental Toughness

At this point in time the most commonly used instruments for standardized MT research are the Mental Toughness Questionnaire MTQ48 (Clough et al., 2002) and the Sports Mental Toughness Questionnaire SMTQ (Sheard et al., 2009), which will both be applied in this study. A strong positive correlation ($r = .75$) between MTQ48 and SMTQ was found by Crust and Swann (2010), yet 44% of the questionnaires' variance could not be

explained, leaving the authors with the question whether the instruments measure different aspect of MT.

2.3.1.1. Mental Toughness Questionnaire

The MTQ48 (Clough et al., 2002) consists of 48 items which can be categorized into four dimensions, challenge, commitment, control and confidence. Control and confidence are divided into two further subscales, control of life and emotional control and interpersonal confidence and confidence in one's abilities. Items have to be rated along a 5-point Likert-scale, ranging from "strongly disagree" (1) to "strongly agree" (5). A total MT score will be calculated, such as a separate score for every dimension and dimension's subscales. High values signify a high anxiety threshold, a strong self-belief and confidence in one's abilities, resilience against stress and a high competitiveness.

2.3.1.2. Sports Mental Toughness Questionnaire

Consisting of 14 items, which can be categorized into three dimensions confidence, constancy and control, the SMTQ (Sheard et al., 2009) resembles the MTQ48. Items have to be rated along a 4-point Likert-scale, ranging from "not at all true" (1) to "very true" (4).

Confidence: Six items of this subscale "*measure athletes' belief in their own abilities to achieve goals and be better than their opponents*". (Crust & Swann, 2010, p. 2)

Constancy describes an athlete's "*determination, personal responsibility, an unyielding attitude, and ability to concentrate*". (Crust & Swann, 2010, p. 2)

Control describes the athlete's "*perception that one is personally influential and can bring about desired outcomes with particular reference to controlling emotions*". (Crust & Swann, 2010, p. 2)

The SMTQ's strong resemblance to the MTQ48 and therefore a high convergent validity was proven by Crust and Swann (2010), who found the instruments to correlate significantly. Sheard et al. (2009) also support claimed discriminant validity through low to moderate correlations of MT measured by the SMTQ with related, yet distinct concepts. However, the authors urge the necessity to further explore construct validity of the SMTQ.

2.3.1.3. Trait Robustness of Self-Confidence Inventory (TROSCI)

Mentally tough athletes have to be equipped with a certain set of psychological skills, including an unshakeable self-belief. A high class athlete needs to be able to maintain self-confident even in the face of inconvenient, unexpected experiences. This ability can be measured by the TROSCI (Beatie et al., 2011), an inventory consisting out of twelve items which have to be rated along a 9-point Likert-scale. High scores represent higher levels of self-confidence in general and more stable levels of self-confidence prior to competition.

2.3.2. Buss and Perry's Aggression Questionnaire – Physical Aggression Scale

Buss and Perry's Aggression Questionnaire (1992) emerged out of a pool of 52 items, which were rated by 1253 psychology students. Using factor analysis, 29 diagnostically conclusive items were picked, representing the four dimensions physical aggression, verbal aggression, anger and hostility. Construct validation was determined by correlations between self-assessment and external assessment. In this study the focus will be on physical aggression, a dimension consisting of nine items which have to be rated along a 5-point

Likert-scale reaching from “never or hardly applies to me” (1) to “very often applies to me” (5). High scores implement a strong readiness to physically harm another person. Males generally show significantly higher scores in physical aggression than females.

2.3.3. Implicit Association Test (IAT) – Aggression

The Implicit Association Test (IAT: Greenwald et al., 1998) Aggression is a computer-based measure to assess implicit (i.e., automatic) aggression. Due to social desirability humans tend to manipulate test scores in a questionnaire towards more accepted or desirable behaviors. This phenomenon can occur deliberately or subconsciously. To avoid such tampering implicit measures could be the key. Activating spontaneous affective reactions, implicit measures provide information about uncontrolled factors crucial for a certain behavior rather than informing about reflected processes (Bluemke & Zumbach, 2007).

To measure implicit aggression, one word stimuli appear at a time on the computer's screen and have to be categorized into either “me” or “not-me” categories by pushing certain keys. The next task is to categorize word stimuli to the categories “aggression” or “peace”. These two tasks are part of the rehearsal process, the tasks presented subsequently serve as the testing process. Participants have to categorize appearing terms into merged categories (i.e., associations) “me or aggression”, “not-me or peace” and in reverse. The measure behind the IAT's task procedure is response latencies. The rationale behind the IAT is that strong associations (e.g., “peace” and “me” or “aggression” and “not-me”) lead to faster reactions during the categorization process than weak association strengths.

The standard metric used to interpret IAT results is *D*. The individual effect size results by “*dividing the difference between the test block means by the standard deviation of all the latencies in the two test blocks*” (Greenwald, Nosek, & Banaji, 2003, p.201). *D* scores

can be positive or negative, ranging between -2 and $+2$. A score of 0 indicates no preference for a category. In this study, low D scores indicated a participant associating aggression with herself. For the purpose of better understanding, scores were reversed for analysis.

2.3.4. Sex Role Identity Scale (SRIS)

Storm's (1979) SRIS consists of three feminine items and three masculine items, which have to be rated on a 5-point Likert-scale. SRIS overall score results by reversing the three feminine items' score and adding the scores of the three masculine items. A high score signifies a highly masculine and little feminine self-concept.

2.3.5. Coren Lateral Preference Inventory (CLPI)

The Coren Lateral Preference Inventory (Coren, 1993) serves to identify laterality aspects. Preferences of handedness, footedness, eyedness and eardness can be detected. For this study's purpose information about handedness and footedness only was collected. Twelve questions identify handedness and an additional four questions footedness, which can be answered with left (-1), right (+1) or both (0). Preference of laterality can be determined by the overall score, which lies between -12 and +12 and -4 and +4.

2.3.6. 2D:4D Digit Ratio

Measurement of the digit ratio can be made directly (see Manning, 2002a) or via hand scans or copies. In this study, participants' hands were scanned by the test administrator with the HP Photosmart 5510 scanner. Participants were asked to remove interfering objects like

watches, rings or tape and lay one hand at a time onto the scanner, splaying out the thumb and keeping the remaining fingers closed. To shield from light and increase picture quality, crinkled aluminum foil was placed on the back of the hand. Scans were taken in gray scale mode, 300dpi, checked for errors (too much pressure of the palm, wrong finger positioning, etc.) and saved under each participant's assigned number.

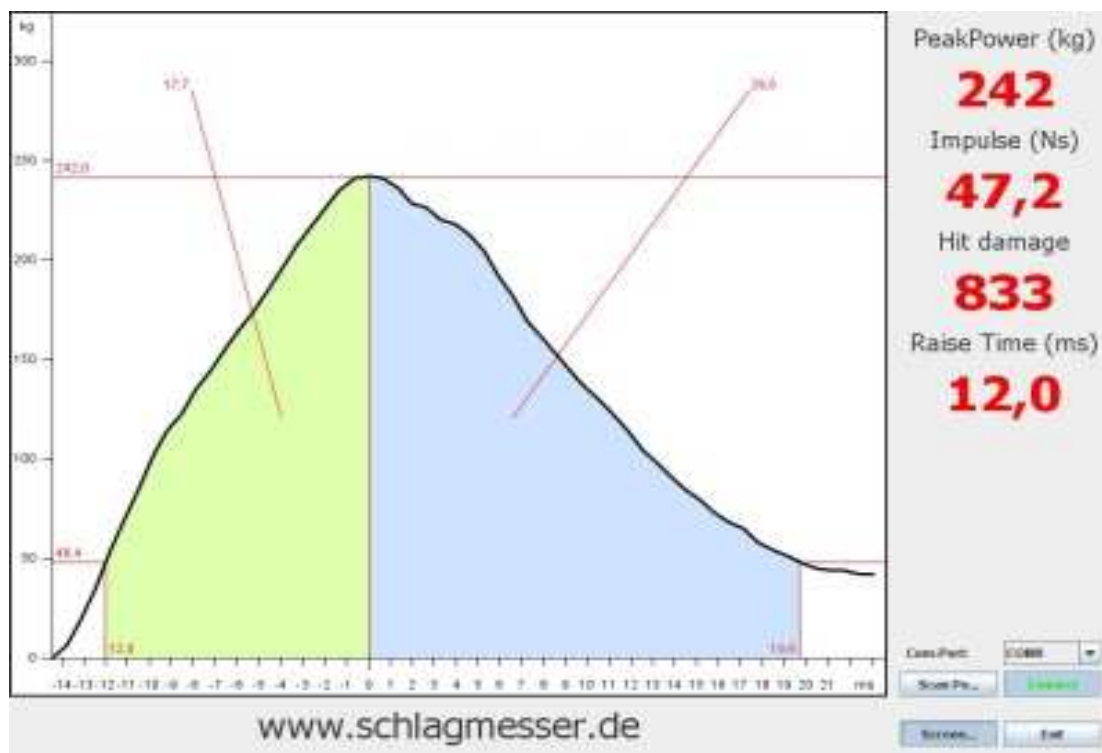
To determine digit ratio, the computer program AutoMetric Version 2.2 (DeBruine, 2006) was used. For this purpose length of the second (index) and fourth (ring) finger is measured from the middle of the fingertip excluding nails down to the middle of the skin fold closest to the palm. 2D:4D ratio is the quotient of the second divided by the fourth finger. To assure inter-rater reliability measurement was executed by two independent individuals.

2.3.7. Handgrip strength

Handgrip strength was found to be a valid predictor for body morphology, past aggressive behavior, health status, recovery from injury, muscle mass and percentage of body fat in males, but not in females (Gallup et al., 2007). Being a physiological variable, handgrip strength varies depending on age, sex, weight and height (Koley & Kaur, 2011). Through muscle contraction of the hand and forearm, handgrip strength proved to be an objective indicator of upper limb functionality (Balogun, Akomolafe, & Amusa, 1991). Data were acquired using a standardized digital handgrip dynamometer (Bremshy EH101). Participants had to squeeze the dynamometer as strongly as possible while standing up straight, shoulders and arms relaxed, not touching the thighs or flexing the arm in the process. Both hands were tested alternately, resulting in four scores for each person. Scores were presented in kilogram.

2.3.8. Punching Power

Punching Power describes the amount of momentum a person can put into a punch and is required to achieve a knockout. In this study, peak power was measured with the computer-based instrument SCHLAGMESSER Basic. The instrument acquires data about peak power, impulse and hit damage. Peak power is being transformed by the program for better understanding and is presented in kilogram. It describes the maximum vertical power impinging on the pad. The impulse can be described as mass multiplied by speed. Participants had to stand in front of the pad in their typical stance and had to perform three single punches on each side. Between each punch they were asked to correct their posture to achieve optimal results.



Ill. 3 Output [http://www.schlagmesser.de/images/stories/screencapture7_small.jpg]

2.3.9. Achievement Level

To objectify achievement level, participants were separated into three equal groups depending on the number of fights they competed in until point of inquiry. Approximately a third had competed in one to three fights, a third in four to ten and a third in eleven or more fights. For better understanding groups were labeled Newcomer, Amateur and Professional. Rankings were discussed but found to be little informative due to the multitude of different organizations.

Results

3.1. Data Analysis

Data analysis for the present study was completed using the statistic program SPSS 19.0 for Windows. Demographic data were analyzed for means, standard deviation and distribution. Internal consistency was determined through reliability analysis.

3.2. Reliability Analysis

3.2.1. Intraclass Correlation

The intraclass correlation (ICC) describes the extent to which two variables measure the same thing. In present study digit ratio was measured by two independent individuals, Livia Plettenberg and Nadine Steinfatt. Independent measurements for the digit ratio 2D:4D were found to strongly correlate showing ICCs of .87 and .93. Corresponding *F* values were significant ($p < .001$, $df = 86$).

ICC values of .96 and .93 for left and right handgrip strength were excellent as expected, as were ICC values of .95 and .94 for left and right peak punching power.

3.2.2. Internal Consistency

To evaluate an instrument's internal consistency, item homogeneity has to be analyzed. It is characterized by Cronbach's α , a coefficient commonly used as an estimate of the reliability of a psychometric test. Cronbach's α for MTQ48, SMTQ, BPAQ-Physical Aggression, TROSCI, SRIS and CLPI – Hand and the lowest and highest corrected item - total correlation of each scale are presented in Table 1.

Table 1. Cronbach's α and corrected item – total correlation

Instrument	Cronbach α	Lowest Corrected Item – Total Correlation	Highest Corrected Item – Total Correlation
MTQ48-overall	.89	.04 (26)	.69 (39)
MTQ48-control	.66	.07 (26 & 34)	.60 (45)
MTQ48-control-life	.55	.03 (33)	.47 (41)
MTQ48-control-emotion	.59	.12 (26)	.52 (45)
MTQ48-confidence	.80	.18 (24)	.63 (8)
MTQ48-confidence-abilities	.72	.20 (24)	.52 (16)
MTQ48-confidence-interpersonal	.78	.39 (28)	.61 (20)
MTQ48-commitment	.67	.19 (22)	.54 (39)
MTQ48-challenge	.70	.26 (40)	.53 (48)
SMTQ-overall	.82	.26 (7)	.60 (12)
SMTQ-control	.59	.23 (7)	.49 (4)
SMTQ-confidence	.67	.25 (1)	.52 (13)
SMTQ-constancy	.56	.27 (8)	.45 (12)
TROSCI	.89	.41 (5)	.71 (8)
BPAQ – physical aggression	.82	.40 (7)	.68 (2)
SRIS	.87	.64 (4)	.72 (1)
CLPI - hand	.91	.41 (11)	.86 (7)

Overall MTQ48 reliability was good at .89, subscale reliabilities ranged from .66 to .80 with MTQ48-control having the least internal consistency. Even though items 3, 26 and 34 reached very questionable corrected item – total correlations, elimination would have affected Cronbach's α to an inconsiderable extent.

Overall SMTQ reliability was good at .82, whereas the subscales' internal consistencies were relatively low ranging from .56 to .67.

TROSCI, BPAQ – Physical Aggression, SRIS all had good reliabilities at .89, .82 and .87. CLPI – Hand had an excellent internal consistency of .91. Reliabilities would have remained stable in case of elimination of weak corrected item – total correlation items, therefore all questionnaires remained unchanged.

For analyzing internal consistency of the IAT – Aggression, split-half reliability was calculated. After Spearman-Brown correction, an excellent split – half reliability estimate of .90 was found.

3.3. Results regarding Mental Toughness

3.3.1. Comparing MTQ48, SMTQ and TROSCI

In the present study, MT was measured using the standardized questionnaires MTQ48, SMTQ and TROSCI. To identify the relation between overall MTQ48 and SMTQ a product-moment-correlation was calculated.

Pearson's r of .82 describes a significant positive correlation between these two instruments. The subscale MTQ48 – Commitment, all three subscales of the SMTQ and the TROSCI did not fulfill the assumption of normality, so further process required Spearman correlation. All correlation coefficients are presented in Table 2.

The subscales' highest correlations were found between MTQ48-control and SMTQ-control ($\rho = .57$), MTQ48-confidence and SMTQ-control ($\rho = .48$) and MTQ4-commitment and SMTQ-constancy ($\rho = .64$). SMTQ-confidence did not correlate significantly with any other scale.

Correlations between TROSCI and MTQ48 or SMTQ were significant at .56 and .63, even though SMTQ-confidence did not correlate significantly with TROSCI.

Table 2 Correlation coefficients MTQ48, SMTQ & TROSCI

	MTQ48 overall	MTQ48 control	MTQ48 confidence	MTQ48 commitment	MTQ48 challenge	TROSCI
SMTQ-overall	.82**	.71**	.69**	.66**	.65**	.63**
SMTQ-control	.59**	.57**	.48**	.37**	.44**	.59**
SMTQ-confidence	-.032	-.12	.00	.12	.02	-.29
SMTQ-constancy	.54**	.38**	.42**	.64**	.42**	.37**
TROSCI	.56**	.48**	.56**	.41**	.31	1

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

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

3.3.2. Comparing Mental Toughness Means

To compare MT means of this study's sample with the sample of Nicholls et al. (2009) and Sheard et al. (2009), independent groups *t*-tests were carried out. Female fighters showed in both tests significantly higher MT than other female athletes ($t(85) = 2.87, p < .05$ and $t(85) = 2.27, p < .05$).

Between groups, a significant difference was found only for the SMTQ subscale constancy between Amateurs and Professionals ($t(85) = 1.05, p < .05$). For all other MT scales, no differences were detected.

3.3.3. Mental Toughness, Aggression and Digit Ratio

Pearson's r between $-.13$ and $.07$ for MTQs and BPAQ- Physical Aggression and IAT- Aggression indicate no significant correlations between MT and aggression.

Correlation coefficients between $-.04$ and $.11$ for digit ratio and MTQs show no significant correlations.

3.4. Results regarding Digit Ratio

To investigate the relation between digit ration and sex role identity, a product-moment-correlation was calculated to examine these variables. Consistent with the meta-analytical results of Voracek et al. (2011), a correlation coefficient of $-.02$ for the left hand and $-.14$ for the right hand did not show any significant relation between digit ratio and sex role identity.

Consistent with the findings of Gallup et al. (2007), showing a strong correlation between HGS and digit ratio in males but not in females, no significant correlation was found ($r = .09, r = -.06$).

3.5. Results regarding Laterality

To examine whether laterality would make a substantial difference in success in Thai boxing, stance, CLPI – hand and CLPI – foot were correlated with the outcome variable wins. Stance significantly correlated with CLPI – hand ($\rho = .36$). Stance, CLPI – hand and CLPI –

foot showed no significant correlation with the outcome variable wins ($\rho = .06$, $\rho = -.02$, $\rho = -.14$).

3.6. Results regarding Aggression

In normal populations, women tend to avoid physical aggression and choose a more indirect way to express aggressive emotions (Hess & Hagen, 2006). Female athletes practicing full contact combat sports were expected to consider expressing physical aggression more often. To test this hypothesis, participant's means of BPAQ-Physical Aggression were compared to the norming sample's means. Using an *independent samples t*-test, results ($t(85) = 4.60$, $p < .05$) showed that female Thai boxers were significantly more willing to carry out physical aggression ($M = 21.4$, $SD = 7.0$). Compared to men of the norming sample, female Thai boxers showed significantly less willingness to carry out physical aggression ($t(85) = 3.32$, $p < .05$).

Correlations between years of practice and BPAQ-P ($\rho = .03$) and IAT- Aggression ($\rho = -.02$) were insignificant. To compare aggression means between groups, independent groups *t*-tests were executed. Comparison between Newcomer and Amateur ($t(85) = -.27$, $p > .05$) was close to significance, Amateur compared to Professional ($t(85) = .732$, $p < .05$) turned out to be significant for BPAQ- Physical Aggression. There was no significant difference between groups for IAT-Aggression ($t(85) = -.42$, $p < .05$; $t(85) = -.27$, $p < .05$).

To analyze the relation between BPAQ- Physical Aggression and IAT- Aggression, a product-moment-correlation was calculated. Pearson's r of .08 was not significant, showing no correlation between these two instruments.

3.7. Results regarding Handgrip Strength

In a sample of 61 female college students, Gallup et al. (2007) found no significant correlation between physical status, aggression and HGS. Given the fact that the sample consisted of non-athletes, HGS was correlated in present study with BPAQ- Physical Aggression, IAT- Aggression, SRIS, biceps circumference, punching power and training intensity.

Pearson's r of $-.27$ between HGS- right hand and implicit aggression and $.22$ between HGS- right hand and sex role identity were significant.

The correlation coefficients, controlled for height and weight, between HGS and punching power, flexed biceps circumference and training intensity are presented in Table 3. Height needed to be controlled due to existing correlations between height and HGS – left after controlling weight effects.

Table 3. Correlation coefficients controlled for height and weight

	Handgrip Strength right	Handgrip Strength left	Punching Power right	Punching Power left	Flexed Biceps Circumference left	Flexed Biceps Circumference right	Training Intensity
Handgrip Strength right	1	.85**	.34**	.29**	.49**	.56**	.34**
Handgrip Strength left	.85**	1	.24*	.34**	.46**	.48**	.21*

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

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

3.8. Results regarding Punching Power

Contrary to expectations, punching power did not significantly correlate with weight ($\rho_{\text{lead hand}} = .02$; $\rho_{\text{back hand}} = .13$). Also, no significant correlation between years of practice and punching power was found ($\rho_{\text{lead hand}} = .17$; $\rho_{\text{back hand}} = .08$). Correlations between punching power, HGS, flexed biceps circumference and training intensity were significant. Correlation coefficients of punching power and HGS are presented in Table 3. Correlation coefficients of punching power, flexed biceps circumference and training intensity are presented in Table 4.

Table 4. Correlation coefficients punching power, flexed biceps circumference and training intensity

	Flexed Biceps Circumference left	Flexed Biceps Circumference right	Training Intensity
Punching Power left	.31**	.28**	.22*
Punching Power right	.30**	.32**	.39**

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

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

Furthermore, maximum punching power of the lead and back hand correlated significantly with the knockout rate ($\rho_{\text{lead hand}} = .49$; $\rho_{\text{back hand}} = .37$).

3.9. Results regarding Achievement Level

The main focus of this study was to investigate the importance of MT, digit ratio and other variables determining success in Thai boxing. Before conducting regression analysis the dependent variable, in this case the number of wins, was correlated with every gathered variable. Significant correlations with the dependent variable were found for the number of

fights in general ($\rho = .93$), years of training ($\rho = .49$), training intensity ($\rho = .57$), punching power_{lead hand} ($\rho = .46$), punching power_{back hand} ($\rho = .42$), MT ($\rho = .22$), MT-Commitment ($\rho = .22$), SMT ($\rho = .22$), height ($\rho = -.23$), weight category ($\rho = -.31$) and actual weight ($\rho = -.26$).

Due to the samples distribution according to Lotka's law, ordinary linear regression was ineligible. A generalized linear model was chosen to identify predictors of achievement level. Several options were tried, resulting in a gamma distribution showing the best model fit. Outcome variable was the number of a fighter's wins. Groups Newcomer, Amateur and Professional were inserted as a factor, while the variables previously found to correlate with the number of wins were inserted as covariates. Results are presented in Table 5. The best model fit resulting in Akaike's Information Criterion AIC of 329.58 was found with all covariates included.

Table 5. Generalized linear model (Gamma)

Source	Hypothesis Test				
	B	Std. Error	Wald Chi-Square	df	Sig.
Intercept	6.75	3.09	4.78	1	.29
Number of fights	.46	.07	47.21	1	> .001
Height	-.03	.02	2.60	1	.11
Weight (actual)	-.05	.04	2.25	1	.13
Weight category	.04	.04	.4	1	.33
Years of training	-.05	.04	2.05	1	.15
Training intensity	.05	.04	1.72	1	.19
Punching power _{lead hand}	-.278E-5	.003	.000	1	.995
Punching power _{back hand}	.008	.002	10.37	1	.001
Via KO	.61	.23	7.22	1	.007
MT	.44	.47	.86	1	.36
MT - Commitment	.12	.38	.10	1	.76
SMT	-.25	.33	.57	1	.45

Out of all covariates included, only the number of fights, punching power of the back hand and knockouts could be identified as predictors with significant explanatory value.

Comparing the groups Newcomer, Amateur and Professional applying repeated contrasts, no significant differences were found, even though the differences between Amateur and Professional were substantial. Results are presented in Table 6.

Table 6. Results for group comparisons

Repeated		Contrast	Std. Error	Wald Chi-Square	df	Sig.
Contrast		Estimate				
Newcomer	vs.	.15	.35	.19	1	.66
Amateur						
Amateur	vs.	2.43	1.41	2.98	1	.08
Professional						

The Omnibus Test, a test to compare the fitted model against the intercept-only model, was found significant, which means that the fitted model has greater predictive value than the intercept-only model.

Discussion

4.1. Mental Toughness

The results found measuring MT were inconclusive. Overlaps between subscales claiming to measure different aspects of MT were found, at the same time did SMTQ-confidence lack a significant correlation with any MTQ48 scale or the TROSCI. Overall MTQ48, MTQ48 subscale confidence and overall SMTQ did show a significant conformity with the TROSCI, suggesting that the MTQ subscale confidence and TROSCI measure the same construct but also indicating a strong overlap between certain other subscales and the TROSCI. These findings lead to the conclusion that further research and psychometric analysis regarding these instruments is necessary.

As expected, female combat sport athletes showed significantly higher MT in both MT questionnaires compared to other female athletes, indicating that MT influences a person's preference for a certain sport. Given the fact that Nicholls et al. (2009) did not find any difference in MT between contact and non-contact sports, further research including a possible third-category of full contact combat sports is suggested.

A willingness to accept high physical risk (Crust & Keegan, 2010) is associated with high MT and was expected to positively correlate with physical aggression and implicit aggression. However, no significant correlation was detected, implying no coherence between MT and aggression.

According to previous research both MT (Gucciardi et al., 2009) and digit ratio (Voracek et al., 2009), were already associated with a strong sporting performance, not only in males but also in females. The expected correlation between MT and digit ratio could not be demonstrated in this study.

Previous research showed that results about possible effects of MT on sporting achievement were inconsistent (Gucciardi et al., 2009; Nicholls et al., 2009). An independent groups *t*-test showed no significant difference in MT expect for SMTQ- Constancy between Amateur and Professional. Even though overall MT scores of both instruments correlated significantly with the outcome variable wins ($\rho = .22$), MT did not have significant predictive value. Possible explanation could be the already significantly higher MT in female fighters compared to other female athletes, suggesting a lack of distinction for upper range test scores of MT instruments. Also plausible seems the necessity to differentiate between several MT constructs in different sports (Bull et al., 2005), therefore suggesting a lack of appropriately specific items and subscales in existing MT questionnaires.

4.2. Digit Ratio

All stated hypotheses in this study concerning digit ratio needed to be rejected. Consistent with the findings of Voracek et al. (2011) no coherence of digit ratio and sex role identity was found. Also consistent with previous research of Gallup et al. (2007), no correlation between HGS and digit ratio in females was detected.

Previous research indicated a significant coherence between digit ratio and success in several sports (Bescos et al., 2009; Voracek et al., 2009). Pokrywka et al. (2005) found evidence to support the idea of digit ratio correlating with sporting achievement, even though differences between elite athletes and non-elite athletes were too small to be significant. Since this study's participants all actively compete, differences between groups were, consistent with the findings of Pokrywka et al. (2005), insignificant. Digit ratio of both hands did not correlate with the outcome variable wins, showing no effect or predictive value towards success in Thai boxing.

4.3. Laterality

In several different sports, left-handedness was identified as a substantial advantage (Dufour & Moller, 1996; Grouios et al., 2000; Holtzen, 2000; Raymond et al. 1996). Gursoy (2009) found left-handedness to significantly benefit boxers in competition. Given the use of all limbs in Thai boxing, a significant advantage of southpaws over orthodox fighters was in question, resulting in no significant beneficial effect of left-handedness towards success rate.

4.4. Aggression

The issue of aggression in sports is of great importance, based on the necessity to compete and possess certain aggressiveness and on the other hand to distance athletes of the image of an aggressive bully. Previous research is inconclusive whether contact sport athletes possess greater aggressiveness and certain sports encourage aggressive behavior or no differences between contact sport athletes and controls exist (Lemieux et al., 2002). Regarding Thai boxing, active physical aggression is necessary to successfully compete and was therefore expected to be higher in participants than in norming sample's females. Expectations were met, female fighters showed significantly higher willingness to carry out physical aggression in everyday life than other females, however, scores were still significantly lower than scores of average males. A review of Edalati, Redzuan, Mansor and Talib (2010) showed females to be equally aggressive on a physical level as males, concluding that social desirability leads to unsolicited distortion. Female combat sport athletes deal with physical aggression on a regular basis and hence might have fewer reservations declaring the use of physical aggression than other women.

Regarding the possible enhancement of aggression due to practicing full contact combat sports, a correlation between years of training and aggression was executed. Also, a comparison in level of aggression between groups Newcomer, Amateur and Professional should provide an indication whether social learning theories (Bandura, 1973) or catharsis theories (Bushman et al., 1999) seem more plausible. No significant correlations between both aggression instruments and years of training were detected, suggesting neither an enhancing nor decreasing effect of participation in full contact combat sports on aggression. Despite comparison between Newcomer and Amateur suggests an insignificant enhancement of aggression through participation in combat sport competition, comparison between Amateur and Professional indicates a significant decrease in aggression through increased participation. Heiny (2012) found similar evidence for a decrease in aggression of Judoka participating more often in competition. For this reason both learning theories and catharsis theories seem plausible. Differences between Newcomer and Amateur were insignificant, yet big enough to claim a temporary learning effect of aggression which transitions into channeling negative emotions into sports rather than everyday situations.

Pearson's r of $-.08$ was insignificant, showing no coherence between BPAQ- Physical Aggression and IAT-Aggression. High scores in directly measured aggression do not imply high scores in implicitly measured aggression.

4.5. Handgrip Strength

Gallup et al. (2007) found HGS to be a considerable indicator for physical health, blood testosterone levels, lean body mass and aggressive behavior in males but not in females. However, the study's sample consisted of female college students, not athletes.

Present study's author suggested a possibly different outcome if tested on female athletes. HGS of the right hand did indeed correlate fairly with implicit aggression ($r = -.27$) and sex role identity ($r = .22$), implying that a higher HGS correlates with lower implicit aggression scores and a more masculine self-perception. Since implicit aggression does not correlate with the physical aggression scale of Buss and Perry's (1992) questionnaire, HGS cannot be interpreted as an indicator for physical aggressive behavior but for aggressiveness in general. High HGS of the right hand also indicated a masculine sex role identity. Results of Baucom et al. (1985) stated that high testosterone levels correlated with a masculine self-perception. These results lead to the conclusion that HGS could be a possible indicator for testosterone levels in female athletes.

HGS, being an indicator for physical health (Gallup et al., 2007) and upper limb functionality (Balogun et al., 1991) was expected to correlate strongly with punching power, flexed biceps circumference and training intensity. Controlling for height and weight, a fair coherence between training intensity and HGS, punching power and HGS and a strong relation between flexed biceps circumference and HGS were found, suggesting HGS of both hands to be a proper indicator for upper limb functionality in female athletes.

4.6. Punching Power

Contrary to expectations, physical condition seemed of much bigger importance than mere weight or duration of practice. Punching power did not correlate with either weight or years of training, implying that punching power results from current physical fitness and active training. This assumption is supported by fairly high correlations between punching

power and HGS, flexed biceps circumference and training intensity, which are all indicators for training status.

Punching Power highly correlated with the outcome variable wins, the connection to achievement level will be discussed below.

4.7. Achievement Level

So far, previous research was unable to provide evidence that there is one MT construct, applicable for every sport. Gucciardi et al. (2009) claimed that MT is of high importance to successfully perform in competition, whereas Nicholls et al. (2009) claim to have found no such connection. In present study, MT fairly correlated with the outcome variable wins, although the construct did not sustain in regression analysis.

Out of all variables included in the generalized linear model, solely the number of fights a fighter had competed in, punching power of the back hand and knockout rate proved to be eligible as predictors with explanatory value. Looking at the number of fights and the years of practice a fighter had, only the number of fights turned out to predict success rate. This implies that fighting experience is of greater importance than training experience and fighters need to develop a certain routine in competition to successfully transition previously acquired skills.

“Everyone has a plan until they get punched in the face.” (Mike Tyson, n.d.) According to general opinion, punching power is of great necessity to win a fight, acting as a factor of intimidation and distraction, if not ending a fight via knockout. Punching power of

the back hand, which is known to be stronger than the lead hand, turned out to significantly predict the outcome variable wins.

Logically consistent, the knockout rate, ending a fight prematurely, is a significant predictor towards success.

A comparison between groups Newcomer, Amateur and Professional revealed no significant difference regarding predictors and outcome variable. However, differences between Amateur and Professional were substantially bigger than between Newcomers and Amateurs and close to significance. Since Thai boxing is a relatively young sport in Europe, especially for females, bigger differences might occur over the years.

4.8. Strengths and Weaknesses of this Study / Suggestions

Considering the low percentage of female competitors in Thai boxing, the number of 87 participants is a success. Even though a great percentage of the continental European Union was covered, more participants and especially more professional fighters could be found in Great Britain, given the greater popularity of martial arts. This should be considered for further research.

The short period of time in which data were collected minimized the possibility of progress for later tested participants. All participants seemed highly interested and motivated during testing which certainly can be considered as a strength.

A weakness turned out to be the long duration of the testing, suggesting the reduction of variables collected to mental toughness, aggression, HGS and punching power in the future. Another weakness appeared to be the different setting, given the fact that many female

athletes were tested alone or in pairs of two, but others in a group group of up to 14. This was unavoidable to reduce participants' expenditure of time, but might be considered in further research.

An important suggestion for further research would be the measurement of not only peak punching power, but punching power over a period of time. A fight can last up to 15 minutes, indicating the increasing importance of strength endurance over time.

Interesting to investigate would be aggression's role in male Thai boxers. Heiny (2012) found a decrease in aggression in more experienced Judoka, an effect especially pronounced in female Judoka. Both studies' results lead to the question if experience in combat sports reduces aggression in both men and women.

This study could not replicate results concerning MT of former researches, indicating that full-contact combat sports possibly require a different form of MT. The long duration of the MTQ48 was often criticized by participants, showing also the importance of finding a shorter version of a MT questionnaire.

This study provides results concerning MT and other important variables in the unique context of Thai boxing, leading to interesting questions yet to be answered. Hopefully this is a step towards accepting full contact combat sports, in this particular case Thai boxing, as a complex sport much rather than seeing it as an act of brutality.

Summary

In the present study, 87 female Thai boxers participated in the measurement of certain demographical, psychological and physiological factors which were assumed to play a major role in achieving success. Athletes from Austria, Germany, the Netherlands and Switzerland partook, having competition experience ranging from 1 to 66 fights. Participants were divided into groups Newcomer (one to three fights), Amateur (four to ten fights) and Professional (eleven or more fights). Groups differed significantly in willingness to conduct physical aggression in everyday life, having Newcomers show insignificantly less physical aggression than Amateurs, and Professionals showing significantly less physical aggression than Amateurs and Newcomers. This finding implies that both social learning theories (Bandura, 1979) and catharsis theories (Bushman, Baumeister & Stack, 1999) are plausible, learning theories playing a more important role for amateur athletes and catharsis theories playing a substantial role for professional athletes. Compared to normal population, female fighters showed a significantly higher readiness to conduct physical aggression, although this result might be explained by combat sport athletes' frequent contact with physical aggression and a more casual way to deal with it.

Physical factors had a strong interconnection, indicating that punching power, flexed biceps circumference and HGS share an underlying necessity of good physical conditioning in order to be high.

This study served to investigate the influence of psychological constructs on success in Thai boxing. However, no coherence between MT or any other psychological construct and achievement level could be demonstrated, implying that the items measuring MT might not be adequate for measuring MT in Thai boxing.

Zusammenfassung

In der vorliegenden Studie nahmen 87 weibliche Thaiboxerinnen an der Erfassung von demographischen, psychologischen und physiologischen Faktoren, die eine bedeutsame Rolle in Hinsicht auf den Erfolg im Wettkampf haben sollen, teil. Kämpferinnen aus Österreich, Deutschland, Holland und der Schweiz nahmen teil und wiesen eine Kampferfahrung von einem bis 66 Kämpfen auf. Die Teilnehmerinnen wurden nach Erhebung in die Gruppen Newcomer (ein bis drei Kämpfe), Amateur (vier bis zehn Kämpfe) und Professional (elf oder mehr Kämpfe) unterteilt. Signifikante Gruppenunterschiede wurden bei der Bereitschaft zur Ausübung von physischer Aggression im Alltag entdeckt, wobei Newcomer weniger physische Aggression als Amateure aufzeigten, Professionals jedoch die geringste. Dies deutet auf die Plausibilität von sozialen Lerntheorien (Bandura, 1979) als auch von Catharsis Theorien (Bushman, Baumeister & Stack, 1999) hin, wobei Lerntheorien im Anfangsstadium der Sportausübung eine größere Bedeutung zuzuweisen ist und Catharsis Theorien eine größere Bedeutung für professionelle Sportler aufzuweisen scheinen. Verglichen mit der Normalpopulation zeigten Kämpferinnen eine significant höhere Bereitschaft zur Ausübung physischer Aggression im Alltag, obwohl dieses Ergebnis unter Umständen durch den regelmäßigen Kontakt mit physischer Aggression und einem freieren Umgang damit erklärt werden kann.

Physische Variablen Schlagkraft, angespannter Bizepsumfang und HGS wiesen eine starke gegenseitige Verbindung auf, ein Ergebnis, das einen potentiellen zu Grunde liegenden Faktor wie hervorragende physische Fitness wahrscheinlich erscheinen lässt.

Diese Studie diente der Erforschung von psychologischen Konstrukten und deren Einfluss auf den Erfolg im Thaiboxen. Allerdings ließ sich keine Verbindung zwischen MT oder anderen psychologischen Konstrukten und dem Erfolgsniveau feststellen, so dass davon

auszugehen ist, dass die Items der zur Erfassung der MT verwendeten Instrumente nicht geeignet sind um MT bei Thaiboxerinnen festzustellen.

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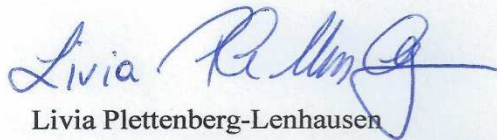
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Eidesstattliche Erklärung

Ich bestätige, die vorliegende Diplomarbeit selbst und ohne Benutzung anderer als der angegebenen Quellen verfasst zu haben. Weiters ist dies die erste dieser Art und liegt nicht in ähnlicher oder gleicher Form bei anderen Prüfungsstellen auf. Alle Inhalte, die wörtlich oder sinngemäß übernommen wurden, sind mit der jeweiligen Quelle gekennzeichnet.



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Wien, im Mai 2013

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