THE ASSOCIATIONS AMONG SELF-COMPASSION, SELF-ESTEEM, SELF-CRITICISM, AND CONCERN OVER MISTAKES IN RESPONSE TO BIOMECHANICAL FEEDBACK IN ATHLETES

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ABSTRACT

This study primarily focuses on the associations among self-compassion, self-esteem, self-criticism, and concern over mistakes in the context of athletes' responses to biomechanical feedback on their sprint performance. Participants (Female = 20, M_{age} = 19.8 years; Male = 28, M_{age} = 23.6 years) performed four sets of 40-meters sprint test and received biomechanical feedback on their sprint time, step length, step frequency, and trunk sway at the end of each trial. Psychological factors self-compassion, self-esteem, self-criticism, and concern over mistakes were measured before the sprint test. Post self-criticism and emotions, thoughts, and reactions were measured after the sprint test through online questionnaires. The results showed that self-compassion and self-esteem had similar relationships to healthy reactions, thoughts, and emotions for athletes after receiving and implementing biomechanical feedback. After controlling for self-esteem, self-compassion predicted unique variance only for personalizing thoughts (R^2 = .117, ΔR^2 = .056, p<.05) and one of the reactions (i.e., "I kept the feedback in perspective"; R^2 = .137, ΔR^2 = .134, p<.05). Baseline self-criticism and concern over mistakes were negatively related to self-compassion and self-esteem, and positively related to post self-criticism. A within-between repeated measure ANOVA with time and sex as within and between subject factors showed a significant improvement in sprint time (F [1.67, 76.78]) = 21.61, p < .001), step length (F [2.43, 111.79] = 22.72, p<.001), and front to back sway (F [2.73, 125.64] = 8.10, p<.001) after the first sprint set, while there were no significant differences between second, third, and fourth sprint performances. A moderated regression analysis between the first and fourth sprint time variables revealed that the level of self-compassion was not a moderator for the change in sprint performance (R^2 = .642, ΔR^2 = .10, p>.05). Future research is needed to explore self-compassion and athletes' responses to feedback through a variety of emotionally challenging scenarios and different feedback modes.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Introduction and Literature Review

1.1 Synergy Between Sports Biomechanics and Sports Psychology

The multifaceted relationship between sport performance and the human body and mind makes both physical and psychological aspects of human nature important considerations to achieve success. Studies have shown the positive effects of psychological preparedness on sports performance (Bolotin & Bakayev, 2017; Church et al., 2017; Vazne, 2008) and the role of psychological characteristics in talent identification and development of sports and exercise (Elferink-Gemser et al., 2004; MacNamara & Collins, 2015; MacNamaraet al., 2010; Morris, 2000). To the best of my knowledge, there is no study that specifically focuses on how specific psychological characteristics can influence the athletes' responses to the biomechanical feedback during sport-specific skills performance. Biomechanical feedback provides objective technical information in order to enhance performance by offering more efficient techniques, mostly delivered to athletes after performance completion (Harfield et al., 2014). Although, studies have shown the positive effects of feedback on sports performance (Baudry et al., 2006; Mauger et al., 2009; Sigrist et al., 2013), coping with feedback and the effort of implementing it during both competition and training can be challenging for athletes.

The current study has made an attempt to bridge sports biomechanics with sports psychology, to see how psychological characteristics such as self-compassion, self-esteem, self-criticism and concern over mistakes can predict the sport performance followed by receiving biomechanical feedback.

1.2 Biomechanical Analysis and Sport

Biomechanics is a broad field of study that analyses the movement of living systems and the effects of forces applied to the body during movement (McGinnis, 2013; Robertson, 2011). Hatze (1974) defined biomechanics as the mechanical study of the structure and function of biological systems which include plants, animals, and humans. The field is as varied; ranging from a focus on "the biomechanical analysis of Olympic sprinters" (Mann & Herman, 1985) to "the biomechanical analysis of horses running on different tracks" (Chateau et al., 2010).

The applications of biomechanics to study human movement can be roughly categorized into two main themes: clinical biomechanics and sports biomechanics. Clinical biomechanics explores the cell, tissue, organ, and body system biomechanics through medical and clinical assessments (Hamill et al., 2012). For example, it can be used to assess the effects of clinical conditions such as cerebral palsy or stroke on gait patterns (Coker et al., 2010; Mulroy et al., 2003), or to evaluate treatment outcomes following a rehabilitation program (Donovan et al., 2016). It can also help people with amputations by informing designs or analysis of artificial limbs and braces (Klute, 2000; Vickers et al., 2008).

The contribution of biomechanics in sports involves analysis of human movement during sports and exercises in order to enhance performance or reduce the risk of injury (Brukner, 2012; Hall, 2019). Sports biomechanics research covers a broad spectrum, including skill acquisition (Portus & Farrow, 2011), modeling and simulation (Bezodis et al., 2015), developing sports equipment (Stefanyshyn & Wannop, 2015), and rehabilitation and injury prevention (Fortenbaugh et al., 2009). Sports biomechanics analysis can be done with basic equipment, and the processing of data can be relatively simple. For example, for biomechanical analysis of a sprinter's running technique, parameters like stride length, stride frequency, and acceleration can be measured by filming the performance with a camera. More advanced equipment, such as force plates or motion capture systems, can be used to perform complex biomechanical analysis. As an example, Slawinski et al. (2010) conducted a biomechanical analysis to compare elite and well-trained sprinters during a sprint start. They used a motion analysis system consisting of 12 digital cameras to capture the 3D kinematics. The velocity and acceleration of centre of mass extracted from the motion analysis system' data were used to calculate the rate of force development and impulse during the pushing phase on the starting block and first two steps. The results showed that the force development and the impulse were significantly higher in elite compared to well-trained sprinters. As another example, Bezodis et al. (2007) used a high-speed camera (perpendicular to the direction of the sprint) and a force plate to explore the variations in joint kinetics in maximum velocity sprint running. The results revealed that, during the propulsive phase of stance, the step velocity was linked to the positive work generated by the ankle joint. Biomechanical analysis can be used for any sport to recognize the mechanics of skills and develop an understanding of the mechanisms underlying more efficient performance (Lees & Nolan, 1998).

Regardless of the diversity in sports, most of the research that uses biomechanical analysis to improve sports performance can be generally grouped in four different categories:

1. Studies that analyze the mechanisms leading a good performance of a sport skill. These studies provide detailed biomechanical knowledge to understand the important characteristics of ideal performance, such as movement pattern, strength, force generation, etc. For instance, Spratford et al. (2009) performed a biomechanical analysis on movement patterns of preferred and non-preferred side dives in goalkeepers. The result revealed that a non-preferred side dive resulted in greater lateral rotation of the pelvic and thorax. These over rotations resulted in different ankle and knee joint moments compared to the preferred side.
2. Studies that analyze the use of different techniques or equipment to execute a specific skill, usually among a group of athletes with the same level of athleticism (e.g., elites, well-trained, amateur). These studies are usually focused on understanding the effects of the most efficient tools or strategies to perform a skill. For example, Escamilla et al. (2001) analyzed the squat lift with varying stance width among national powerlifters. The results show significantly greater knee and hip moments in a wide stance compared to a narrow stance.
3. Studies that compare athletes with different level of athleticism performing a similar sports task. These studies look to provide information that can help accelerate the learning and development of sport performance. Hebert-Losier et al. (2014) analyzed the jumping and hopping techniques among elite and amateur orienteering athletes. They found that elite athletes perform a superior stretch-shortening cycle and generated maximal vertical forces faster than amateur athletes. These findings show the benefits of lower body training in amateur athletes in enhancing running and sprinting performance.
4. Studies that look at the effects of biomechanical feedback on sport performance. These types of studies are focused on developing and accessing biomechanical feedback tools to help athletes perform specific sports tasks. For example, Mendoza and Schollhorn (1993) improved junior sprinters' starting technique by using biomechanical feedback. They measured technical parameters regarding the block position, horizontal velocity at take-off, and the time to 10-meters; they also provided visual biomechanical feedback displayed on a computer screen about 20 seconds after each attempt. The results showed significant improvement in starting performance, while there was no significant change in horizontal velocity at take-off and the time to 10-meters.

The research presented in this thesis will focus on biomechanical feedback and sport performance (i.e., Category 4 above) with a specific focus on sprinting.

1.3 Biomechanics of Sprinting

Running is a fundamental form of human movement and is one of the most popular sports activities that can be applied to a wide range of sports situations, such as sprinting or chasing a ball/opponent in competitive sports (Fong et al., 2007; Van Mechelen, 1992). Sprinting is high intensity running over a short distance (Faude et al., 2012; Mann & Haggy, 1980). Sprinting technique is one of the significant characteristics that usually is used for evaluating athletic performance in elite and nonelite athletes (Lorenz et al., 2013). The objective of sprinting is to cover a required distance as fast as possible (Mann, 2013). There are a wide range of studies that examine the biomechanics of sprinting. Most of the sprinting studies are focused on the biomechanical characteristics of different start positions (Bezodis, 2009; Coh et al., 2007; Okkonen & Hakkinen., 2013; Schot et al., 1992), the effects of footwear stiffness on sprint performance (Oleson et al., 2005; Roy & Stefanyshyn, 2006; Stefanyshyn & Fusco, 2004; Willwacher, 2016), and the biomechanics of the maximum velocity and acceleration phase of sprinting (Bezodis et al., 2015; Nagahara et al.,2014; Salo et al., 2005).

The most common measurements used to analyze sprinting performance are the total sprint time and spatiotemporal stride characteristics (Bezodis et al., 2019; Salo et al., 2011). Stride length and stride frequency play a key role in achieving maximum velocity in sprinting (Majumdar & Robergs, 2011; Paruzel-Dyjaet al., 2006). Sprint velocity is the product of step length and step frequency, and it can be improved by increasing step length and/or step frequency (Hunter et al., 2004; Majumdar & Robergs, 2011). Salo et al. (2011) investigated the step characteristics of elite 100-meter sprinters. The average step length and step frequency over the whole 100-meter were analyzed. The results showed that both step length and step frequency were the main contributors in faster running velocities, and the researchers proposed that athletes reliant on step length have different training needs than athletes reliant on step frequency. Otsuka et al. (2016) studied the contributions of step length and step frequency towards sprinting velocity in a sprint race compared with speed training. The results revealed that the average sprinting velocity was significantly greater in the race than in speed training, due to a significantly higher step frequency in the race.

In addition to spatiotemporal parameters, other biomechanical factors can influence sprinting performance. Movement of the center of mass is related to the forces that propel a sprinter forward (Kugler & Janshen, 2010). Since the trunk represents a large percentage of the body mass, trunk movement can play a role in sprint performance. Current elite coaching theory suggests that unnecessary side-to-side movement or anteroposterior sway will decrease velocity and yield in poor sprinting performance (Mann, 2013). However, there is still a need for research to fully understand how trunk sway influences sprint performance.

In spite of the importance of proper sprinting techniques in track and field athletes (Cunningham et al., 2013; Jones et al., 2009), athletes involved in fields of sport other than track and field (e.g., soccer, basketball, football) are often not trained to sprint properly. In most of the team-based sports, a higher speed is advantageous, and athletes spend time improving their running velocity (Dawes & Lentz, 2012). For speed development in non-track athletes, coaches need to dedicate enough time and effort in developing the mechanics of acceleration by proper acquisition of sprint mechanics (Dawes & Lentz, 2012; Spinks et al., 2007), rather than focusing only on adjustments in foot placement and step rate (Dawes & Lentz, 2012). This highlights the importance of receiving and implementing biomechanical feedback on sprinting performance.

1.4 Biomechanical Feedback

Feedback refers to qualitative or quantitative information provided to the learner before, during, or after an attempt to perform a motor skill (McGill., 2001). There is an ambiguity regarding the effectiveness of different types of feedback on motor skill acquisition. The feedback that is specifically related to performance results is known as "outcome feedback" (Adams, 1987; Magill, 2011; Salmoni et al., 1984). Outcome feedback could be intrinsic or extrinsic. Intrinsic feedback is the information provided by the athlete's sensory and perceptual systems that are always a part of performing motor skills (McGill, 2001; Wulf, 2007b). Extrinsic feedback provides information that athletes do not receive from their neuromuscular system and cannot be explained without an external source (Schmidt & Wrisberg, 2008; Utley & Astill, 2008). The extrinsic feedback presented by an external source, such as a coach or trainer, about motor performance and result is known as augmented feedback (Schmidt & Wrisberg, 2008). For example, coaches give verbal information to the athletes based on their observations in order to modify athletes' performance or show them the video of their performance and provide instructions in regards to improving their sports execution (Baudry et al., 2006). Augmented feedback can be provided in different ways: visual (e.g., screen), auditory (e.g., speaker), haptic (e.g., vibrotactile actuator), or a combination of ways (Akamatsu et al., 1995).

Augmented feedback can be classified into the knowledge of result (KR) and the knowledge of performance (KP). Knowledge of result is defined as augmented information about the outcome of performance in relation to an environmental goal, while knowledge of performance is defined as augmented information about the movement characteristics that result in the performance outcome (Mononen et al., 2003; Van Vliet & Wulf, 2006). KR feedback is usually used for tasks that require scaling of a single degree of freedom movement or a single dimension response (Newell et al., 1987; Salmoni et al., 1984). For example, a sprinter might receive the time it takes to run a certain distance. KP feedback usually provides information about the kinematics or kinetics of a movement and movement pattern (Newell & Carlton, 1987; Schmidt & Young, 1991). For example, a sprinter might receive information about the length, frequency, or the pattern of their steps. Due to the complexity of the sports skills, KR feedback might not be the most effective type of feedback, and more information about the interaction among movement segments or kinetics and kinematics of the sports skills could be beneficial to achieve proper outcomes (Mononen et al., 2003; Schmidt & Lee, 1999).

Both KR and KP feedback can be categorized based on the time point at which the feedback is provided: concurrent feedback (i.e., provided during the task execution) and terminal feedback (i.e., provided after the task execution). Concurrent feedback can prevent cognitive overload in the early learning phase, facilitate the discovery of the new structure of the movement, and ease the understanding of a complex motor task (Huegel & O'Malley, 2010; Wolpert et al., 2011). Although studies show the effectiveness of concurrent feedback on performance enhancement in cyclic motions, such as running and cycling (Broker et al., 1993; Mauger et al., 2009; Sanderson & Cavanagh, 1990), receiving concurrent feedback can degrade motor learning due to developing dependency on the feedback (Schmidt, 1991; Sigrist et al., 2013). Previous studies show the benefits of concurrent feedback on skill acquisition and performance improvement while the feedback was present, but these performance improvements were decreased in the absence of the feedback (Annett, 1959; Sigrist et al., 2013). Although receiving terminal feedback might not have as strong effects as concurrent feedback on the performance during skill acquisition, studies show the effectiveness of terminal feedback on learning enhancement even in the absence of the feedback (Schmidt et al., 1989; Sigrist et al., 2013; Winstein & Schmidt, 1990; Wulf & Schmidt, 1989).

Sigrist et al. (2013) conducted a study to examine the effectiveness of learning a complex, three-dimensional rowing-type task with concurrent visual, auditory, or haptic feedback compared to terminal visual feedback. The result showed that terminal visual feedback was more effective due to its contribution to improving task-relevant aspects compared to concurrent feedback that promoted the corrections of task-irrelevant errors. Also, the improvements due to receiving concurrent visual and haptic feedback were only presented during training with feedback. There was no significant improvement in non-feedback trials.

Another consideration that should be taken into account when developing feedback is the frequency of the feedback. The optimal frequency of the feedback might depend on the movement complexity and athletes' experience (Eriksson et al., 2011; Wulf et al., 1998). Although learning of complex skills might benefit from a higher frequency of feedback, especially for novices (Wulf & Shea, 2002), studies prove the effectiveness of reducing the amount of feedback in facilitating learning (Ishikura, 2008; Park et al., 2000; Winstein & Schmidt, 1990). Reducing the frequency of the feedback can enhance learning because having no-feedback trials might engage athletes in more error detection intrinsic processes and decrease the dependency on feedback (Winstein & Schmidt, 1990; Wulf & Shea, 2002; Young & Schmidt, 1992).

Broker et al. (1993) examined the effects of augmented feedback on the learning of kinetic patterns in cycling. They provided feedback for the right-pedal shear force for one-minute trials and delivered feedback in two different ways. For each trial, participants attempted to accelerate the bicycle during the first 30 seconds, then attempted to match the criterion shear force pattern during the last 30 seconds. The first group of subjects received concurrent feedback during the final 30 seconds of each trial, and the other group received a summary of feedback between each trial (i.e., during the rest period between trials). The results indicated that presenting a relatively small amount of terminal feedback resulted in large changes in the kinetic pattern.

Another important consideration is that receiving feedback can alter the attentional focus of athletes (Wulf, 2007b) because an athlete's focus of attention has a significant influence on motor performance and learning (Beilock et al., 2002; Castaneda & Gray, 2007; Wulf, 2007a). Attentional focus in sports refers to what cue, stimuli, instruction, or feedback the performers focus on while executing a skill (Wulf, 2007b). The athletes' attentional focus can be directed internally to their body movement (i.e., focus on the movement itself, or movement process), externally on the effects that their movement has on the environment (i.e., focus on the movement effects, or movement outcome), or neutrally by which there is no conscious focus (Benz et al., 2016; Porter et al., 2010; Wulf et al., 1998; Wulf, 2007b). The studies show the superiority of the external focus of attention in enhancing learning and retention of motor skills (Benz et al., 2016; Ille et al., 2013; Porter et al., 2015; Wulf, 2007b). The athletes' focus of attention could be influenced by the feedback they might receive. Feedback provided on body movements and movement coordination directs athletes' attention internally; while receiving feedback about movement effects or outcomes will result in an external focus (Benz et al., 2016; Wulf, 2007b). Shea and Wulf (1999) examined the learning advantages through external-focus feedback. They provided augmented visual feedback for a balance task on the stabilometer. The results showed that receiving augmented feedback improves balance. Also, the external focus (with and without feedback) was more effective than the internal focus. Wulf et al. (2002) demonstrated that not only the external-focus feedback can increase learning rates superior to internal-focus feedback, but more than that, the withdrawal of internal-focus feedback results in performance enhancement.

1.5 Psychological Factors in Athletic Performance

Although studies have shown a "powerful effect" of augmented feedback on performance (Baudry et al., 2006, Burke et al., 2006; Eriksson et al., 2011), coping with feedback, and the effort of implementing it during both competition and training, could be challenging for athletes (Mononen et al., 2003). One specific challenge is that not all athletes receive and implement feedback similarly. Studies show that athletes with a high level of concern over mistakes have more negative thoughts before the competition, as well as show negative reactions to mistakes (Emmons, 1993; Frost & Henderson, 1991; Koivula et al., 2002). Athletes that are overly concerned about mistakes and have difficulties with forgetting errors are more prone to psychological disorders, such as anxiety and burnout, that potentially decrease sports performances (Hill et al., 2008; Koivula, 2002). Relatedly, Stoeber and Eysenck (2008) found that receiving feedback increases self-criticism. This is important because self-criticism is associated with increasing concern for other people's evaluations and opinions, concern over mistakes, and fear of failure that could have negative effects on an athlete's performance (Emmons, 1993; Koivula et al., 2002).

Self-criticism is well established as the main indicator of dysfunctional perfectionism (Hill et al., 2008; Stoeber & Otto, 2006; Taranis & Meyer, 2010). Perfectionistic concerns are associated with self-criticism, concerns over making mistakes, performance-avoidance goals, competitive anxiety, and fear of failure (Stoeber & Eysenck, 2008; Stoeber, 2011). Also, studies show that self-criticism is positively associated with, and increases the risks of, distrust and dissatisfaction (Zuroff & Fitzpatrick, 1995), competitive anxiety (Koivula, 2002), and burnout (Hill et al., 2008). Self-criticism is also negatively associated with self-esteem (Fox, 2000), self-definition (Blatt, 2004), and autonomous motivation, and it is positively related to poor adaptation (Shahar et al., 2003). As the above information attests to, athletes are consistently faced with the potential for failure in meeting expectations in training and competitions (Blatt, 1990); and therefore, need strategies to effectively cope with feedback that they receive about their performance.

Self-compassion (i.e., being kind and understanding toward oneself when faced with personal shortcomings and weakness; Neff, 2003a) has been suggested as a potential resource to help athletes cope with some of the difficult challenges that they might endure (Ferguson et al., 2014; Mosewich et al., 2013; Reis et al., 2015; Sutherland et al., 2014). Studies show that self-compassion is associated with a wide range of healthy behaviors such as positive affect, increased life satisfaction, and reduced anxiety (Neff, 2009; Neff & McGehee, 2010). Specifically, in athletes, self-compassion is positively associated with intrinsic motivation towards exercise (Magnus et al, 2010) and negatively associated with shame and fear of failure (Mosewich et al., 2011). Ferguson et al. (2014), showed that self-compassion is positively associated with well-being. In reaction to emotionally difficult sport situations, athletes with higher level of self-compassion had higher positivity and perseverance, rather than athletes with lower level of self-compassion. Self-compassion can also play an important role in emotional distress regulation relative to a sports failure (Ceccarelli et al., 2019; Leary et al., 2007; Reis et al., 2015). There is an accumulating body of evidence to support the effectiveness of self-compassion for athletes dealing with emotionally difficult situations. Leary et al (2007) used a sport specific hypothetical scenario to measure the participants' reactions, thoughts, and emotions in response to an emotionally difficult situation in sport (i.e., "Being responsible for losing an athletic competition for your team", p. 891-892). The results showed that self-compassion predicted unique variance beyond self-esteem for reactions, thoughts, and emotions to a negative sports event. Reis et al (2015) used sports specific hypothetical and recalled scenarios to measure the associations between self-compassion and women athletes' responses to the emotionally difficult sport situations. The result showed that women with higher level of self-compassion react, think, and feel in a healthier way.

Whereas research on self-compassion has recently increased, self-esteem has a longer history of study as a potential resource for athletes (Mosewich et al., 2011; Neff & Vonk, 2009). Self-esteem, "is an evaluation of our worthiness as individuals, a judgment that we are good, valuable people" (Neff, 2011, p. 1), and the development of self-esteem has been established as one of the beneficial ways to foster a positive sport experience (Boyer, 2008) and overcome negative challenges (Neff & Vonk, 2009). Despite all the benefits of self-esteem in promoting positive self-evaluations (Boyer, 2008), happiness (Baumeister et al., 2003), self-confidence (Tilindienė et al., 2014), and motivation (Harter, 1999) in athletes, relying solely on self-esteem might not be ideal (Mosewich et al., 2011; Neff, 2011; Reis et al., 2015). High levels of self-esteem are related to the "better- than- average effect", resulting in unrealistically positive self-evaluating thoughts and increasing the potential of putting others down to boost oneself up (Neff, 2011). Also, developing self-esteem is difficult since it is resistant to change (Swann, 1996), and attempts to increase self-esteem are often not successful (Neff, 2003a; Neff, 2011).

Magnus et al. (2010) found that even though self-compassion and self-esteem are complementary concepts and share significant common variance, self-compassion has benefits over and beyond self-esteem in well-being in female exercisers. More specifically, self-compassion can promote positive feelings without self-evaluations or comparisons with others (Neff & Vonk, 2009). As a result, it is likely no surprise that higher levels of self-compassion have been associated with greater life satisfaction, emotional intelligence, social connectedness, learning goals, wisdom, personal initiative, curiosity, happiness, optimism, and positive affect, as well as less self-criticism, depression, anxiety, fear of failure, thought suppression, perfectionism, performance goals, and disordered eating behaviors (see Neff, 2009, for a review).

Studies show the positive effects of self-compassion interventions on decreasing self-critical thoughts and concern over mistakes in both athlete and non-athlete samples (Gilbert & Procter, 2006; Jopling, 2000; Mosewich et al., 2013; Neff, 2003a). Specific to the present study, Neff (2003b) found that self-compassion is negatively associated with the observed discrepancy between performance and standards. Also, there was a negative association between self-compassion and self-criticism. Further, Reis et al. (2015) measured the association between self-compassion and women athletes' responses to emotionally difficult sport-specific scenarios. The results showed that women with a higher level of self-compassion react, think, and feel more healthily in response to challenging situations. In addition, Mosewich et al. (2013) investigated the effects of a self-compassion intervention on self-criticism and concern over mistakes in highly self-critical women athletes. They found that a self-compassion intervention effectively decreases self-criticism, rumination, and concern over mistakes, which suggests self-compassion might be a relevant resource to help athletes deal with biomechanical feedback that has the potential to present emotional challenges for them.

1.6 Study Purposes and Objectives

Although studies support the benefits of biomechanical feedback in athletic performance improvement, psychological factors such as self-compassion, self-criticism, and concern over mistakes may moderate how athletes implement this feedback; this, however, has not been studied to date. This study aimed to explore how athletes emotionally respond to objective feedback, and specifically how their levels of self-compassion, self-esteem, self-criticism, and concern over mistakes were associated with those responses. Hence, the purpose of the current study was to explore how athletes respond to terminal biomechanical feedback, and precisely how their levels of self-compassion, self-esteem, concern over mistakes, and self-criticism are associated with those responses. A secondary purpose was to explore whether self-compassion can promote healthy reactions, thoughts, and feelings in response to biomechanical feedback in athletes.

Chapter 2: Methods

2.1 Methodology Overview

This study was an observational, cross sectional, within-between research design. Figure 1 presents an overview of the methodology of the study.

The methods consisted of two phases. In phase I, the biomechanical data of nine University sprinters (5 males, 4 females) were collected using timing gates and inertial sensors during three video-taped 40-meter sprint tests. The biomechanical information was used to establish gold standards for time, step length, step frequency, side-to-side (lateral sway), and front-to-back (anteroposterior sway) trunk movements. These gold standards were used as a reference for biomechanical feedback for the main participants in phase II.

Phase II involved collecting data from the main study participants. It consisted of one 60-minute data collection session for each of the participants. At the start of the session, the levels of self-compassion, self-esteem, self-criticism, and concern over mistakes for each main participant were gathered via online questionnaires completed at the test site. To facilitate the understanding and implementing of feedback for participants, they were first asked to watch a short tutorial video. This video was made by the researcher and provided basic knowledge about the types of biomechanical feedback that participants would receive after each sprint and the way that each feedback is related to performance (e.g., "If you increase your step length, you can run faster"). This strategy also ensured that all participants received the same verbal instructions. Then, participants performed four sets of sprint tests with timing gates and inertial sensors. Participants received biomechanical feedback after each sprint. The feedback contained a visual representation of their trial data in comparison to the gold standards established in phase I. Participants were asked to try to improve their next sprinting performance using the biomechanical feedback that was provided. After performing all four sprints, participants completed online scales to rate how they reacted, felt, and thought in response to the biomechanical feedback. Also, self-criticism level was collected again for each participant at the end of the session through the online questionnaire.

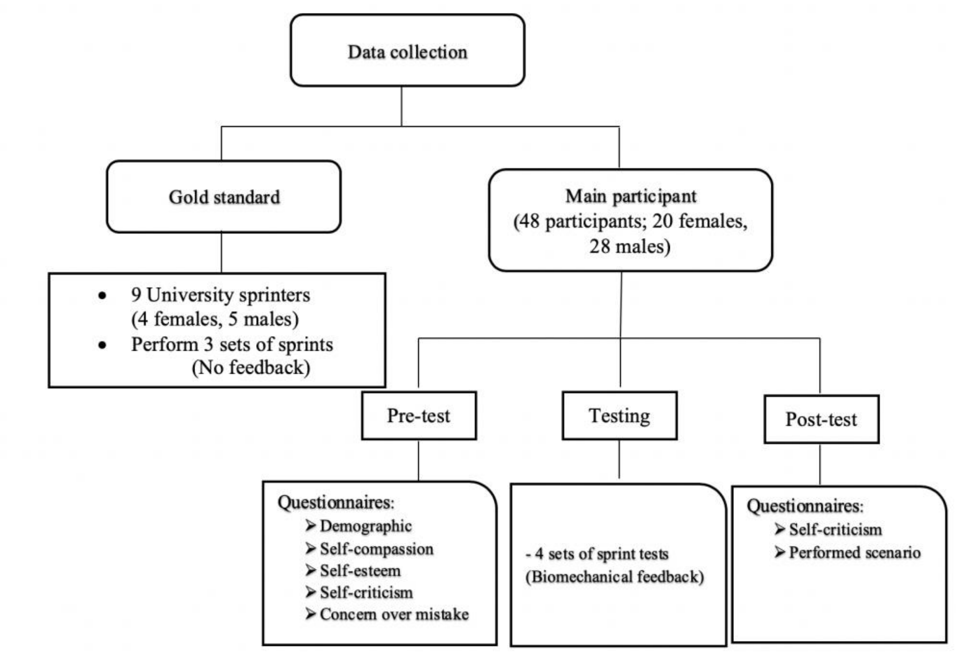

Figure 2.1. Methodology overview

2.2 Hypothesis

The study consisted of three groups of hypotheses based on time point and analysis type.

2.2.1 Hypothesis 1: (Relationships at baseline, before sprint testing)

1.a) Self-compassion should be negatively associated with baseline self-criticism and concern over mistakes in athletes. Previous studies show the positive effect of self-compassion on managing self-criticism in athletes (Mosewich et al., 2013; Reis et al., 2015). Also, the negative relationship between self-compassion and observed discrepancy among actual performance and standards has been established (Neff, 2003b).

1.b) Self-compassion should be positively associated with self-esteem. Studies with women athletes have shown significant relationships between self-compassion and self-esteem (Mosewich et al., 2013; Reis et al., 2015).

2.2.2 Hypothesis 2: (Relationships between variables before and after sprint testing)

2.a) Self-compassion and self-esteem should be negatively associated with self-criticism measured after receiving biomechanical feedback. Previous studies show the negative associations between self-compassion and self-criticism (Mosewich et al., 2013; Neff, 2003b; Reis et al., 2015).

2.b) Self-compassion and self-esteem should be positively associated with healthy reactions, thoughts, and emotions measured after receiving and implementing biomechanical feedback. A positive correlation among the higher level of self-compassion and healthier reactions, thoughts, and feelings of female athletes in emotionally difficult sport-specific situations are documented (Reis et al., 2015).

2.c) Baseline self-criticism and concern over mistakes should be positively associated with self-criticism measured after receiving and implementing biomechanical feedback. Self-criticism is associated with increasing concern over mistakes in athletes (Emmons, 1993; Koivula et al., 2002).

2.d) Baseline self-criticism and concern over mistakes should be negatively associated with healthy reactions, thoughts, and emotions measured after receiving and implementing biomechanical feedback. Reis et al. (2015) showed the positive associations between self-compassion and healthy reactions, thoughts, and emotions in athletes. Also, previous studies highlighted the negative relationship between self-compassion and self-criticism and concern over mistakes (Mosewich et al., 2013; Neff, 2003b; Reis et al., 2015).

2.2.3 Hypothesis 3: (Changes between variables before and after sprint testing)

Athletes with a higher level of self-compassion should have better sprint performance after receiving and implementing biomechanical feedback. Self-compassion as a non-judgmental approach has positive psychological effects, such as decreasing performance anxiety and critical thinking (Neff, 2009), which may lead to better performance. Higher level of self-compassion can decrease the observed discrepancy between performance and standards (Neff, 2003b) and promoting sports performance by decreasing self-criticism and fear of failure (Mosewich et al., 2013).

2.3 Participants

2.3.1 Gold Standard Participants (Phase I)

To establish gold standards for comparison in the feedback, nine elite University of Saskatchewan sprinters (5 male and 4 female) participated in this study. The recruitment of University athletes was done according to a recruitment protocol implemented by the College of Kinesiology and University Athletics. Separate gold standards were created for males and females. The demographic status of the gold standard participants is represented (Table 2.1). Gold standard participants were mainly of White ethnicity and their level of competition varied from regional to national level during past year (Table 2.2).

2.3.2 Main Participants (Phase II)

There were 50 athletes (22 females, 28 males) between 16 to 35 years of age who participated in this study as main participants (Table 2.3). The participants were recruited from the university and the general public (52% from university programs and 48% from community programs). Two females were excluded from the study for different reasons. One of them did not meet the age inclusion criteria (16-35 years old), and the other had incomplete sprint time data. Main participants were recruited via various techniques, such as sending recruitment letters and posters to sport associations, coaches, and university athletes. The main participants were primarily of White ethnicity (Table 2.2). They were involved with variety of team sports (Table 2.4) and had to be enrolled in an organized sport within the past year with at least one training session per week. Their level of competition varied from recreational to national level during past year (Table 2.4).

Table 2.1

Age, Height, and Mass for the Gold Standard Participants

	Sex	*n*	*Range*	*Mean*	*SD*
Age (Years)	Female	5	19-26	22	3.16
	Male	4	19-24	20.4	2.07
Height (Centimeters)	Female	5	167.6-176.8	172.97	4.59
	Male	4	176.8-195	185.52	7.83
*Mass *(Kilograms)*	Female	5	61-68	64.25	2.99
	Male	4	61-86	78.2	10.33

* Mass data was self-reported

Table 2.2

Participant Sociocultural Information

Participant	*Ethnicity*	*n (%)*	
		Female	Male
Gold standard	Indigenous		1 (20)
	White	4 (100)	4 (80)
Main	Arab	1 (5)	1 (3.6)
	Black		2 (7.1)
	Indigenous	2 (10)	
	South east Asian	2 (10)	
	West Asian	1(5)	11 (39.3)
	White	14 (70)	14 (50)

Table 2.3

Main Participant Age, Height and Mass

	Sex	*n*	*Range*	*Mean*	*SD*
Age (Years)	Female	20	16-26	19.8	3.05
	Male	28	16-33	23.57	7.76
Height (Centimeters)	Female	20	156-178.5	167.89	6.00
	Male	28	173.1-196.3	182.38	12.60
*Mass *(Kilograms)*	Female	20	50-75	61.85	8.79
	Male	28	50-107	76.96	12.60

* Mass data was self-reported

Table 2.4

Main Participant Sport Involvement

Sport	*Sex*	*Sport level*						*Total n*
		Recreational	Local	Provincial	Regional	National	Elite	
Soccer	Female	2	1	1	5	1	2	12
	Male	6	6			1		13
Basketball	Female	1						1
	Male	1	2	4	1			8
Volleyball	Female	3	2	1				6
	Male	1	2	1				4
Football	Female							
	Male			1	1			2
Hockey	Female				1			1
	Male	1						1
Total	Female	6	3	2	6	1	2	20
	Male	9	10	6	2	1	0	28
Overall		15	13	8	8	2	2	48

2.4 Procedures

2.4.1 Gold Standard

To establish the gold standard data to incorporate into the main participant feedback, data from nine elite University of Saskatchewan sprinters were measured. The University athletes were recruited and tested separately from the main study participants. Data were collected on an outdoor running track at Griffith Stadium at the University of Saskatchewan. Sprinters were dressed in clothing suitable for sprinting (e.g., shirt and shorts that exposes shins) and wore their sprint spikes for footwear. After a warm-up length of their preference, each sprinter wore three inertial sensors on the trunk and ankles and performed three sets of 40-meter sprints on a straight path at maximum speed. Participants were given three minutes rest time between trials. The University sprinters did not receive any biomechanical feedback about the trials until after all data had been collected, as providing them feedback was not the purpose of the data collection. Their sprint time, stride length, stride frequency, side-to-side, and front-to-back sway were calculated and used as the gold standard data, with separate gold standards established for males and females.

2.4.2 Main Participants

After collecting data from University sprinters and calculating the sex-specific gold standard data, the main participants were tested. Participants dressed in clothing suitable for sprinting (e.g., shirt and shorts that exposes shins) and wore their usual sprint/running shoes. Data were collected on a public indoor running track at the Physical Activity Complex at the University of Saskatchewan.

The participants were first asked to provide information about their demographic status (Appendix A), self-compassion (Appendix B), self-esteem (Appendix C), concern over mistakes (Appendix D), and self-criticism (Appendix E), using online questionnaires supplied on a laptop.

Following a warm-up (i.e., jogging and dynamic stretches), all participants were asked to watch a short video that explained the feedback information that they would receive after each sprint (Appendix F). This was done to standardize the initial instructions. Kinematic data were collected using inertial sensors worn on the participant's trunk and right and left ankles. After preparation, each participant performed four sets of 40-meter sprint tests on a straight path. The time of the first sprint was used to establish the participant's baseline sprint performance. After each sprint, the participant received a combination of KR and KP biomechanical feedback (stride length, stride frequency, side-to-side sway, and front-to-back sway) immediately after completion of the run. This feedback consisted of information comparing their performance for each of the biomechanical variables to the gold standard data. The fourth sprint test established the final performance record for each participant. Three minutes of rest was provided between trials to avoid fatigue. Participants could have more rest time based if requested but none of the participants asked for extra rest time.

At the end of the session, participants completed five questions regarding the importance of receiving feedback and their satisfaction with the feedback they received on their performance (Appendix G). Finally, they completed the online version of self-criticism (Appendix H) (reworded towards the sprint task performed by participants) and performed scenario questionnaires (Appendix I).

2.5 Instruments

2.5.1 Timing and Inertial Sensors

A set of electronic timing gates (Freelap Pro Coach BLE, 0.02 second accuracy, Freelap, USA) were used to time the sprinters' performance over the 40-meter distance. The same timing gates were used for both the gold standard athletes and the main participants. These timing gates used a chip that attached to the athletes' waist on their shorts (Figure 2). The time data transferred from the chip to a transmitter placed at the end of the track. As the athlete passed the transmitter, the time data was sent to a smart phone via Bluetooth connection and then manually recorded. This time was the main performance outcome used for analysis.

The remaining biomechanical feedback data were collected by small, lightweight wearable wireless inertial sensors (Opal, APDM Inc., Portland, OR; 43.7 x 39.7 x 13.7 mm; < 25 grams). The inertial sensors contain three-dimensional accelerometers, gyroscopes, and magnetometers that provide kinematic information about sensor orientation, acceleration, and angular velocity. For this study, no data from the magnetometers were used. The data were collected at a sample rate of 128 Hz and transmitted wirelessly to a PC-based laptop. The participants wore three inertial sensors: on the trunk, right ankle (RA), and left ankle (LA) (Figure 2). The sensors on the ankles were securely fixed by loop and hook fabric straps on the anterior surface of the shin near the ankle to prevent motion artefact noise. These straps did not limit the range of motion of the ankle joint. The trunk sensor was fixed over the sternum using a custom light-weight straps.

Figure 2.2. Inertial sensor configuration (Red arrows). Participants wore a sensor on the anterior side of the distal tibia on each leg and one near the sternum attached using a custom harness. The chip used for timing gates placed on participant's waist

In this study, raw sensor data was used. The angular velocity of RA and LA extracted from sensors was analyzed using a custom algorithm written in MATLAB (R2019a, Mathworks, Natick, MA) to calculate the total number of steps for each trial. The sagittal angular velocity of the RA and LA sensors were first filtered using a 4th order low pass Butterworth filter with a cut off frequency of 5 Hz. Distinct angular velocity peaks associated with each step were then identified using a thresholding technique, which gives a count of the number of steps in the data. Participants began using a stationary standing start just in front of the first timing gate. The step indices were used in conjunction with the trunk resultant acceleration to automatically identify the first step. The externally measured sprint time was then used to determine the number of steps that were part of the 40-meter sprint. Step time was calculated by dividing the step count by the sprint time. The step frequency was calculated as the inverse of step time and multiplied by 60 to express it in units of steps per minute. (i.e., $\text{Step frequency (step/minute)} = \frac{1}{Step\ time\ (seconds)} \times 60$). The average step length was calculated by dividing the 40-meter distance by the number of steps. Then to normalize the step length, the values were divided by each participant's height. The participants received the step frequency and step length, relative to the gold standard, as part of the feedback.

The data from the trunk sensor was used to calculate the side-to-side and front-to-back sway of the trunk using another custom MATLAB routine. Raw trunk angular velocity data in each movement axis was partitioned using the step timing information obtained from the ankle sensors. The angular velocity data for each step was then numerically integrated to obtain the angular displacement (i.e., sway) for each step. The range of motion of both side-to-side sway and front-to-back sway were calculated.

Feedback was given on a laptop screen using a custom MATLAB routine. After each sprint trial, athletes received their step length and frequency data in the form a two row bar graph; the top bar being the sex-matched gold standard data and the lower bar being the participant's performance for that trial (Figure 3). Numerical data for these variables was also presented beside the bar graphs. In addition, explicit text was provided telling the participant how their data differed from the gold standard. For example, for run time they would be told that their time was SLOWER or FASTER than the gold standard. For feedback about side-to-side, and front-to-back sway of the trunk, they received visual feedback in the form of two arcs showing the range of angular movement, again with the gold standard data above the participant data (Figure 3).

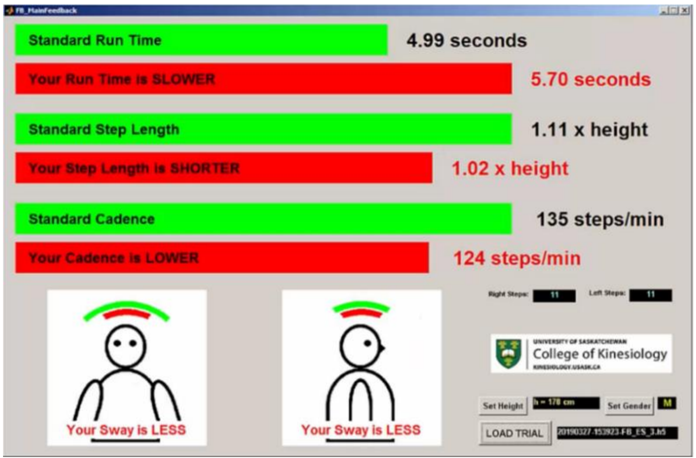

Figure 2.3. Sample biomechanical feedback presented to the main participants. The green bars indicate the sex-matched gold standard data. The red bars indicate the participant's performance for that trial. The bars show run time, then step length, and finally cadence (i.e., step frequency). The step length is normalized to the participant's height. For trunk sway, the green arcs show the side-to-side and front to back gold standard trunk sways. The red arcs show the participant's sway.

To examine if there was any significant change in sprint performance after receiving and implementing feedback, all the data for each trial was saved for further analysis.

2.5.2 Self-Compassion Scale

The athlete version of Self-compassion Scale (SCS-AV) (Killham et al., 2018) was used to measure the baseline level of self-compassion of the participants. The SCS-AV is a modified version of the original Self-compassion Scale (Neff, 2003a) to include the specific language of the sport context. This scale assesses the three components of self-compassion, with each negative and positive aspects of these three main components of self-compassion being categorized as a subscale (Appendix B): Self-kindness vs. Self-judgment, Common humanity vs. Isolation, and Mindfulness vs. Over-identification. Therefore, the SCS-AV consists of 26 items, including six subscales. Ten out of 26 items are related to Self-kindness vs. Self-judgment (five items each, e.g., “I’m tolerant of my own flaws and inadequacies in sport” and “I’m disapproving and judgmental about my own flaws and inadequacies as an athlete”, respectively). Eight items are related to Common humanity vs. Isolation (four items each, e.g., “When I feel inadequate in sport, I try to remind myself that feelings of inadequacy are shared by most athletes” and “When I think about my inadequacies in sport, it tends to make me feel more separate and cut off from the rest of the world”, respectively). The final eight items are related to Mindfulness vs. Over-identification (four items each, e.g., “When I’m feeling down in my sport, I try to approach my feelings with curiosity and openness” and “When I’m feeling down as an athlete, I tend to obsess and fixate on everything that’s wrong in my sport” respectively). The SCS-AV has a scoring scale from 1 (“Almost never”) to 5 (“Almost always”) for each item. To compute the total self-compassion score, the grand mean of all six subscales means is calculated. The internal consistency reliability for the composite and all subscales of original SCS range from α = .82 and α = .93 in samples of women athletes (Ferguson et al., 2014; Mosewich et al., 2011; Reis et al., 2015). The internal consistency reliability of SCS-AV is α = .85 (pre-competition) and α = .88 (post-competition) in women athletes (Killham et al., 2018).

In order to assess the construct validity of the original SCS, Neff (2003b) measured the relationship between the SCS and the more established scales that measured associated constructs. There is a negative correlation between SCS and the self-criticism subscale of the Depressive Experience Questionnaire (DEQ) (r = -.65, p<.01). Additionally, SCS is positively related to the Social Connectedness scale, (r = .41, p<.01), and all subscales of the Trait-Meta Mood Scale (Attention, r = .11, p<.05, Clarity, r = .43, p<.01, and Repair, r = .55, p<.01) (Neff, 2003b). Neff (2003b) found that there was no significant correlation between SCS and the Marlowe-Crowne Social Desirability scale, (r = .05, p = .34).

2.5.3 Self-Esteem Scale

To measure the level of self-esteem in athletes, the Rosenberg Self-Esteem Scale (RSES, Rosenberg, 1965) was used. The RSES is a widely used instrument that has been validated in past studies (e.g., Martin-Albo et al., 2007; Mimura & Griffiths, 2007). The full length RSES scale (Rosenberg, 1965) consists of 10 items (e.g., “I feel that I’m a person of worth, at least on an equal plane with others"). These items are rated based on a Likert-type response scale, from 1 ("Strongly disagree") to 4 ("Strongly agree").

In the current study, the 10-item RSES scale was used (Appendix C). Among these ten items, five items were positively worded (e.g., "On the whole, I am satisfied with myself") and five items were negatively worded (e.g., "At times I think I am no good at all"). The negative items (2, 5, 6, 8, 9) were reverse scored. The mean of all 10 items are used to calculate the composite self-esteem score. The internal consistency reliability (Cronbach's alpha) of the RSES has been well established in studies on different populations. In adolescents (middle school), Choi et al. (2006) and Hagborg (1993) found high internal consistency (α = .88 - .92). Mosewich (2011) found acceptable internal consistency for young women athletes (α = .87).

2.5.4 Concern Over Mistakes Scale

The Sport-Multidimensional Perfectionism Scale-2 (SMPS2) by Gotwals and Dunn (2009) was used for evaluating the level of concern over mistakes (Appendix D). This questionnaire consists of 42 items and assesses the perfectionistic tendencies in athletes. This scale is based on Frost et al.'s (1990) perfectionism framework and includes six subscales: Personal Standards; Concern over Mistakes; Perceived Parental Pressure, Perceived Coach Pressure, Doubts about Action, and Organization. The SMPS2 scale has a scoring scale from 1 ("Strongly disagree") to 5 ("Strongly agree") (Gotwals & Dunn, 2009). Validity evidence for the Sport-MPS-2 has been well established (Gotwals et al., 2010; Gotwals & Dunn, 2009; Mosewich, 2013). In this study, to measure the level of concern over mistakes, only the concern over mistakes subscale of the Sports Multidimensional Perfectionism Scale-2 (Gotwals & Dunn, 2009) was used. Mosewich (2013) found an acceptable internal consistency in the subscale items among women athletes (α = .83). This subscale consists of eight items (e.g., "The fewer mistakes I make in competition, the more people will like me"). For each item, athletes chose a number between 1 ("Strongly disagree") to 5 ("Strongly agree"). The mean scores of these eight items indicated the level of concern over mistakes.

2.5.5 Self-Criticism Scale: Baseline and Post

To measure the level of self-criticism, a self-critical thought scale by Gilbert and Procter (2006) was used. This seven-item scale focuses on frequency, power, intrusiveness, length, and the difficulty of distraction from self-critical thoughts (Appendices E & H). In Gilbert and Procter's (2006) study, participants rated the repetition and severity of self-critical thoughts by "Thinking back over the week" (Gilbert & Procter, 2006, p. 379). In current study, the athletes were asked to complete the baseline self-criticism questionnaire at the beginning of the session and the post self-criticism questionnaire at the end after all of the sprinting trials were done. In order to better suit the purpose of current study, the wording of the questionnaire slightly altered. At the beginning of the session, participants were asked to think back over the year and rate their critical thoughts. For the post self-criticism, after performing all four set of sprinting, participants were asked to think about the biomechanical feedback on their sprinting performance and rate the repetition and severity of self-critical thoughts related to receiving and implementing biomechanical feedback and their ability to manage the consequences.

The self-criticism scale has a scoring scale from 1("Not at all") to 10 ("A lot of the time", "Very powerful", "Very distressed", etc.) (Gilbert & Procter, 2006). For example, to measure the intrusiveness of self-critical thoughts ("How intrusive were your self-critical thoughts?") athletes chose a number between 1 ("Not at all") to 10 ("Very intrusive") (Gilbert & Procter, 2006). The level of self-criticism was measured by the total mean of the scores. The self-critical thought scale is designed based on previous studies involving compassionate self-imagery (Gilbert & Irons, 2004). Although Gilbert and Procter (2006) did not provide broad information about the validity of this scale, the results show that the level of self-critical thoughts has a negative correlation with self-compassion.

2.5.6 Demographic Questionnaire

The demographic questionnaire (Daniels & Leaper, 2006; Mosewich, 2008) was used to collect general information including age, sex, ethnicity, and medical history. This questionnaire also contains information regarding sports involvement (within the last 12 months) and competition level (Mosewich, 2008). To consider the sports participation frequency of athletes, a sports frequency measure was also included (Daniels & Leaper, 2006) (Appendix A).

2.5.7 Performed Scenario Scale

To assess emotions, thoughts, and reactions of the participants after completing the sprint task and receiving biomechanical feedback, participants were asked to reflect upon the performed scenario. The performed scenario was designed based on hypothetical and recalled scenarios used by Leary et al. (2007) and Reis et al. (2015). The hypothetical scenario upon which it was based was as follows: "Being responsible for losing an athletic competition for your team" (Reis et al., 2015, p. 29). Participants were asked to imagine themselves in this scenario, and then answered questions relating to three main components: Emotion, Thought, and Reaction. The recalled scenario was as follows: “The worst thing that has happened to you in sport during the past year that was or was not your fault”. In both cases, participants were asked to rate their emotion, thought, and reaction on a 6-point scale.

To apply the performed scenario in current study, the wording of the hypothetical and recalled scenarios (Leary et al., 2007) was transformed (Appendix I). Participants were asked to consider this scenario: “Indicate the extent to which you reacted/ thought/ felt each of the following reactions/thoughts/emotions about the biomechanical feedback on your sprint performance”. They then rated their emotions (Section 2.5.7.1), thoughts (Section 2.5.7.2) and reactions (Section 2.5.7.3) on various scales similar to Leary et al. (2007). The reactions and thoughts scales used in Leary et al.’s (2007) study were slightly altered to address specifically to the feedback that athletes received on their sprint performance (Table 2.5).

Table 2.5

The Reactions and Thoughts Scales Presented by Leary et al. (2007) and the Modified Scales Used for Performed Scenario

Reactions

Hypothetical Scenario, Leary et al. (2007)	**Question 1, Performed Scenario**
1. Remain *relatively* calm and unflustered 2. Overreact 3. Experience strong emotions but not get carried away *with them* 4. Have no emotional reaction whatsoever 5. Take the *situation* in stride 6. *Leave* the *situation* quickly in order to deal with my emotions 7. Replay the *situation* in my mind *for a long time afterwards*	1. Remain calm and unflustered 2. Overreact 3. Experience strong emotions but not get carried away 4. Have no emotional reaction whatsoever 5. Take the *feedback* in stride 6. *Set aside* the *feedback* quickly in order to deal with my emotions 7. Replay the *feedback* in my mind constantly
Recalled Scenario, Leary et al. (2007)	**Question 2, Performed Scenario**
1. I tried to be kind to myself 2. I tried to make myself feel better 3. I was really hard on myself 4. I kept the *situation* in perspective 5. *I wanted to spend time alone* 6. I expressed my emotions to let off steam 7. I took steps to fix the problem *in a positive way* or *I* made plans to do so 8. I sought out the company of others 9. I gave myself time to come to terms with it 10. *I tried to understand my emotions*	1. I tried to be kind to myself 2. I tried to make myself feel better 3. I was really hard on myself 4. I kept the *feedback* in perspective 5. *I tried to do things to take my mind off of the feedback* 6. I expressed my emotions to let off steam 7. I took steps to fix the problem or made plans to do so 8. I sought out the company of others 9. I gave myself time to come to terms with it

Thoughts

Hypothetical Scenario, Leary et al. (2007)	**Question 1, Performed Scenario**
1. This is awful! 2. Everybody goofs up now and then 3. In the long run, this really doesn't matter 4. I am such a loser 5. *I wish I could die* 6. This is sort of funny 7. I should have expected this would happen	1. This is awful! 2. Everybody goofs up now and then 3. In the long run, this really doesn't matter 4. I am such a loser 5. This is embarrassing 6. This is sort of funny 7. I should have expected this would happen
Recalled Scenario, Leary et al. (2007)	**Question 2, Performed Scenario**
1. I seem to have bigger problems than most people do 2. I'm a loser 3. This isn't any worse than what lots of other people go through 4. Why do these things always happen to me? 5. In comparison to other people, my life is really screwed up 6. *I've had a really bad day-I need to do something nice for myself*	1. I seem to have bigger problems than most people do 2. I'm a loser 3. This isn't any worse than what lots of other people go through 4. Why do these things always happen to me? 5. In comparison to other people, my life is really screwed up 6. *Everyone has a bad day now and then*

2.5.7.1 Emotions: Total Negative Affect

Participants were asked to indicate their feelings based on 16 items pertaining to four emotions: Sadness (sad, dejected, down, depressed), Anxiety (nervous, tense, worried, anxious), Anger (angry, irritated, mad, hostile), and Embarrassment (embarrassed, humiliated, disgraced, ashamed). Participants rated each item based on a six-point scale, 1 ("Not at all") to 6 ("Extremely"), as proposed by Leary et al. (2007). In my study, the total negative affect score was calculated as summation of four emotion scales: Sadness, Anxiety, Anger, and Embarrassment.

2.5.7.2 Thoughts

To evaluate participants' thoughts, they were asked to complete two sets of questions. For first question, they rated the following thoughts on a five-point scale, 1 ("I do not think this thought at all") to 5 ("I kept thinking this thought"): " (a) This is awful! (b) Everybody goofs up now and then, (c) In the long run, this really doesn't matter, (d) I am such a loser, (e) This is embarrassing, (f) This is sort of funny, and (g) I should have expected this would happen".

Leary et al. (2007) performed a principal-axis factor analysis and found that 63% of variance was accounted by four factors: Catastrophizing (e.g., "This is awful!"), Personalizing (e.g., "I am such a loser"; "I wish I could die"), Equanimity (e.g., "Everybody goofs up now and then"; "In the long run, this doesn't really matter"), and Humor (e.g., "This is sort of funny"). These four factors were summed up to calculate the total score.

The second question asked about the degree to which they were thinking in each of the following ways: "(a) I seem to have bigger problems than most people do, (b) I'm a loser, (c) This isn't any worse than what lots of other people go through, (d) Why do these things always happen to me, (e) In comparison to other people, my life is really screwed up, and (f) Everyone has a bad day now and then". The second question was rated on a six-point scale, 1 ("Not at all") to 6 ("Extremely"), and the score of each individual item was used in the further analysis.

2.5.7.3 Reactions

To assess their reaction, participants were asked to complete two sets of questions. For first question, they rated following reactions when they were thinking about the biomechanical feedback on their sprinting performance: "(a) Remained relatively calm and unflustered; (b) Overreacted; (c) Experienced strong emotions but not got carried away with them; (d) Have no emotional reaction whatsoever; (e) Took the feedback in stride; (f) Set aside the feedback quickly in order to deal with my emotions; and (g) Replayed the feedback in my mind for a long time afterward". For each reaction, participants responded on a six-point scale, 1 ("Not at all") to 6 ("Extremely"). Highly reactive statements (i.e., "Overreacted", "Set aside the feedback quickly in order to deal with my emotions", and "Replayed the feedback in my mind for a long time afterward") were reverse scored, and then the score of all items were summed up and create a single factor called behavioral equanimity.

The second question asked about the degree to which they reacted in each of the following ways: "(a) I tried to be kind to myself; (b) I tried to make myself feel better; (c) I was really hard on myself; (d) I kept the feedback in perspective; (e) I tried to do things to take my mind off of the feedback; (f) I expressed my emotions to let off steam; (g) I took steps to fix the problem or made plans to do so, (h) I sought out the company of others, and (i) I gave myself time to come to terms with it". Similar to the first question, a six-point scale, 1 ("Not at all") to 6 ("Extremely") was used and the score of each individual item was used in the further analysis.

2.6 Data Analysis

Statistical analysis was computed using SPSS v22 (IBM Corp. Armonk, NY, USA) with the alpha level set at $p<.05$. Normality was assessed by calculating the Z scores for skewness and kurtosis and comparing them to the standard error of skewness and kurtosis. Values higher than -/+ 2 were considered as significant skewness and kurtosis (Vincent & Wier, 2011).

A one-tailed Pearson correlation analysis was performed to test if the relationships among self-compassion, self-esteem, baseline self-criticism, and concern over mistakes were in the same direction as predicted in Hypothesis 1. Also, to test Hypothesis 2 a one-tailed Pearson correlation analysis was used to determine the correlations between self-compassion, self-esteem, baseline self-criticism, and concern over mistakes with post self-criticism, reactions, thoughts, and emotions measured after receiving and implementing biomechanical feedback. A hierarchical regression analysis was performed to see if self-compassion can predict post self-criticism, reactions, thoughts, and emotions after receiving biomechanical feedback while controlling for self-esteem. The variables that were significantly correlated to self-compassion were considered as dependent variables. The self-esteem scores were entered into the model in the first block. Then, self-compassion scores were introduced in the second block.

For testing Hypothesis 3, a moderated regression analysis was performed with self-compassion as a moderator between the 1st and 4th sprint time variables. The 4th sprint time considered as a dependent variable. The 1st sprint time was entered into the model in the first block. Then, self-compassion scores were introduced in the second block. Finally, to see if self-compassion is a moderator for change in sprint performance, the interaction between 1st sprint time and self-compassion (i.e., 1st sprint Time * Self-compassion) was introduced in the third block.

As a pre required analysis for Hypothesis 3, to see if any significant changes occurred in biomechanical variables after receiving and implementing biomechanical feedback, a within-between 4 (within: sprint repetition) x 2 (between: sex) repeated measures ANOVA was used to examine changes in performance during sprint sets.

Chapter 3: Results

3.1 Descriptive Statistics and Scales Reliabilities

Descriptive statistics and the internal reliabilities for the psychological scales and subscales are presented in Table 3.1. The range, mean, standard deviation, and internal consistency (i.e., Cronbach's alpha) values for self-compassion, self-esteem, concern over mistakes, baseline and post self-criticism, total negative affect, thought, behavioral equanimity, are also shown in Table 3.1. The range of each scale represents the minimum and maximum value of participants' responses.

3.2 Missing Data and Test of Assumptions

Before examining descriptive statistics, data were cleaned, and no missing data were identified across any of the scales and subscales. Thus, data from 48 participants were used for hypothesis testing. Prior to performing correlation and regression analyses, the assumptions of normality, independence of residuals, normality of residuals, and homoscedasticity were examined. The outliers were calculated as values higher than -/+ 2 standard deviations greater or lower than mean (Vincent & Wier, 2011). There were no outliers on any of the scales and subscales. The skewness and kurtosis values are shown in Table 3.

Table 3.1

Descriptive Statistics and Internal Reliabilities of Psychological Scales and Subscales

Variable	*Items*	*Possible Range*	*Range*	*Mean*	*SD*	α
Self-compassion	6*	1-5	2.30-4.60	3.47	0.55	.86
Self-esteem	10	1-4	2.20-3.90	3.20	0.40	.79
Concern over mistakes	8	1-4	1-3.88	2.58	0.87	.87
Pre self-criticism	7	1-10	2.29-7.29	4.35	1.42	.76
Post self-criticism	7	1-10	1-6.14	3.62	1.25	.71
Total negative affect	4	16-96	16-51	20.73	7.78	.86
Thoughts (1st question)						
- Catastrophizing	2	2-10	2-7	2.58	1.23	.55
- Personalizing	2	2-10	2-6	2.79	1.15	-
- Equanimity	1	1-5	1-5	1.56	1.03	.30
- Humorous	1	1-5	1-5	1.73	1.16	-
Thoughts (2nd question)						
- I seem to have bigger problems than most people do	1	1-6	1-3	1.27	0.54	-
- I'm a loser	1	1-6	1-2	1.04	0.20	-
- This isn't any worse than what lots of other people go through	1	1-6	1-6	1.87	1.23	-
- Why do these things always happen to me?	1	1-6	1-2	1.02	0.14	-
- In comparison to other people, my life is really screwed up	1	1-6	1-2	1.15	0.41	-
- Everyone has a bad day now and then	1	1-6	1-6	1.73	1.16	-
Reactions (1st question)						
- Behavioral equanimity	7	7-42	22-37	28.73	3.51	.86
Reactions (2nd question)						
- I tried to be kind to myself	1	1-6	1-6	3.75	1.30	-
- I tried to make myself feel better	1	1-6	1-6	3.45	1.54	-
- I was really hard on myself	1	1-6	1-5	2.23	1.30	-
- I kept the feedback in perspective	1	1-6	1-6	4.52	1.13	-
- I tried to do things to take my mind off of the feedback	1	1-6	1-4	1.50	0.92	-
- I expressed my emotions to let off steam	1	1-6	1-6	1.46	0.99	-
- I took steps to fix the problem or made plans to do so	1	1-6	1-6	4.06	1.69	-
- I sought out the company of others	1	1-6	1-5	1.73	1.16	-
- I gave myself time to come to terms with it	1	1-6	1-5	2.44	1.44	-

Note. For the single items (i.e., personalizing and humorous thoughts, thoughts (2nd question) and reactions (2nd question), the internal reliability values cannot be calculated. * Referring to the summation of subscales mean.

Table 3.2

Skewness and Kurtosis Values of Psychological Scales and Subscales

Variable	$Z_{Skewness}$ *Std.error = .34*	$Z_{Kurtosis}$ *Std.error = .67*
Self-compassion	0.41	- 0.99
Self-esteem	-1.70	0.29
Concern over mistakes	-0.28	- 1.57
Baseline self-criticism	1.25	-1.21
Post self-criticism	0.72	-0.87
Total negative affect	8.31*	12.25*
Thoughts (1st question)		
- Catastrophizing	7.26*	0.87
- Personalizing	3.56*	0.40
- Equanimity	0.34	4.47*
- Humorous	4.35*	1.80
Thoughts (2nd question)		
- I seem to have bigger problems than most people do	5.52*	4.24*
- I'm a loser	13.81*	31.64*
- This isn't any worse than what lots of other people go through	4.47*	2.89*
- Why do these things always happen to me?	20.2*	71.22*
- In comparison to other people, my life is really screwed up	8.66*	13.29*
- Everyone has a bad day now and then	5.59*	5.51*
Reactions (1st question)		
- Behavioral equanimity	0.50	-0.90
Reactions (2nd question)		
- I tried to be kind to myself	-.89	-1.27
- I tried to make myself feel better	-0.40	-1.81
- I was really hard on myself	1.99	-1.15
- I kept the feedback in perspective	-2.85*	1.24
- I tried to do things to take my mind off of the feedback	5.44*	3.62*
- I expressed my emotions to let off steam	8.19*	13.74*
- I took steps to fix the problem or made plans to do so	-1.77	-1.22
- I sought out the company of others	4.84*	3.00*
- I gave myself time to come to terms with it	0.96	-2.08*

Note. Z values were calculated by dividing skewness and kurtosis by standard error to obtain a *z*-value, as recommended by Vincent and Wier, 2011.
*Values higher than +/- 2 were determined as significant skewness or kurtosis.

As represented in Table 3.2, self-compassion, self-esteem, concern over mistakes, and pre- and post self-criticism scales were normally distributed, whereas most of the items in reactions, thoughts, and emotions subscales violated the normality assumption and were positively skewed. Typically, in self-reported scales, the distribution will be skewed if the responses deviate from the midpoint and are drawn toward the minimum or maximum possible values of the scale. For example, in my study, for one of the thoughts, "I am a loser", the majority of participants choose the minimum value on a five-point scale, resulting in a positive skewness. Based on a number of other self-compassion studies in sport, describing that after transforming data substantive conclusions do not change (e.g., Mosewich et al., 2011; Reis et al., 2015), I used the non-transformed scales values in all analyses.

3.3 Test of Hypothesis

3.3.1 Hypothesis 1: Relationships at Baseline, Before Sprint Testing

The first hypothesis focused on predicting the relationships between psychological scales prior to the sprint tests. Hypothesis 1.a predicted that self-compassion should be negatively associated with baseline self-criticism and concern over mistakes in athletes. In contrast, Hypothesis 1.b predicted that self-compassion should be positively associated with self-esteem. As the result show (Table 3.3), there was full support for Hypothesis 1.a and 1.b in that self-compassion was negatively correlated with concern over mistakes and baseline self-criticism, and that there was a positive correlation between self-compassion and self-esteem.

Table 3.3

1-Tailed Pearson Correlations Before Receiving Feedback

	Self-Compassion	*Self-esteem*	*Concern over mistakes*	*Baseline self-criticism*
Self-Compassion	1	.567**	-.687**	-.518**
Self-esteem		1	-.462*	-.504**
Concern over mistakes			1	.504**
Baseline self-criticism				1

** Correlation is significant at the .01 level (1-tailed). * Correlation is significant at the .05 level (1-tailed).

3.3.2 Hypothesis 2: Relationships Between Variables Before and After Sprint Testing

The second hypothesis predicted the relationships between psychological scales and subscales after the sprint tests. Based on this hypothesis, self-compassion, and self-esteem (taken at baseline) should be negatively associated with post sprint self-criticism and positively associated with healthy emotions, thoughts, and reactions. Conversely, baseline self-criticism and concern over mistakes should be positively associated with post self-criticism, and negatively associated with healthy emotions, thoughts, and reactions.

The correlations among all variables after receiving biomechanical feedback are shown in Table 3.4. Supporting Hypothesis 2, post self-criticism was negatively related to both self-compassion and self-esteem, and positively related with concern over mistakes and baseline self-criticism. Further supporting Hypothesis 2, self-compassion and self-esteem were negatively correlated with emotions (i.e., total negative affect) and catastrophizing thoughts, and positively correlated with positive reactions (i.e., "I tried to be kind to myself", and "I tried to make myself feel better"). In addition, a negative correlation was found between self-compassion and both personalizing and equanimity thoughts. Also, self-compassion positively predicted one of the reactions (i.e., "I kept the feedback in perspective"). However, Hypothesis 2 was not supported for humorous thoughts and behavioral equanimity. Also, for all the remaining items of thoughts (2^{nd} question) and reactions (2^{nd} question), no relationship with self-compassion was found.

As predicted, the results show that concern over mistakes and baseline self-criticism were positively related to emotions after receiving biomechanical feedback. Also, concern over mistakes was positively related to catastrophizing thoughts and negatively related to one of the reactions (i.e., "I tried to be kind to myself"). But, Hypothesis 2 was not supported for any other items of emotions, thoughts, and reactions.

Table 3.4

Pearson Correlations of Scales and Subscales

	Self-Compassion	*Self-esteem*	*Concern over mistakes*	*Baseline self-criticism*
Post self-criticism	-.382**	-.355**	.249*	.591**
Total negative affect	-.381**	-.547**	.317*	.305*
Thoughts (1st question)				
- Catastrophizing	-.368**	-.348**	.265*	.018
- Personalizing	-.342**	-.178	.127	.165
- Equanimity	-.242*	-.105	.082	.058
- Humorous	-.033	.019	-.020	-.110
Thoughts (2nd question)				
- I seem to have bigger problems than most people do	-.110	-.239	.181	.199
- I'm a loser	-.189	-.340**	.041	.064
- This isn't any worse than what lots of other people go through	.027	.073	-.100	-.179
- Why do these things always happen to me?	-.037	-.001	-.099	.096
- In comparison to other people, my life is really screwed up	-.060	-.309*	.100	-.002
- Everyone has a bad day now and then	-.105	-.207	.104	-.099
Reactions (1st question)				
- Behavioral equanimity	.226	.329*	-.077	-.147
Reactions (2nd question)				
- I tried to be kind to myself	.380**	.314*	-.327*	-.215
- I tried to make myself feel better	.330*	.316*	-.231	-.182
- I was really hard on myself	-.176	-.242*	.208	.230
- I kept the feedback in perspective	.268*	-.058	-.147	-.013
- I tried to do things to take my mind off of the feedback	.101	-.037	-.091	-.024
- I expressed my emotions to let off steam	-.023	.205	-.004	-.072
- I took steps to fix the problem or made plans to do so	.229	.319*	.104	.049
- I sought out the company of others	.053	-.021	.027	.102
- I gave myself time to come to terms with it	.229	.185	-.088	.021
How important is sprinting performance to your sport?	.049	.099	.218	-.104
How important is sprinting performance to you?	.062	.235	-.030	-.272*
How important is it to receive biomechanical feedback on your sprinting performance?	.031	.137	-.093	-.060
How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?	-.085	-.136	-.025	.040
How good or bad did you feel about your sprinting performance today?	.015	-.216	-.052	.007

** Correlation is significant at the .01 level (1-tailed). * Correlation is significant at the .05 level (1-tailed).

Previous studies show that self-compassion and self-esteem are complementary and share large common variance. To account for this, a series of hierarchical regression analyses were performed to test if self-compassion significantly predicted unique variance above and beyond self-esteem for post self-criticism, reactions, thoughts, and emotions after receiving biomechanical feedback. Regressions were performed for variables that were significantly related to self-compassion (Table 3.5).

Table 3.5

Summary of Hierarchical Regression Analyses Exploring the Influence of Self-Compassion (SCS-AV) Beyond Self-Esteem (SES)

	Predictor variable	B	SE B	ß	R^2	Adjusted R^2	ΔR^2
Post self-criticism	*Step 1: SES*	-1.098	.427	-.355*	.126*	.107	.126*
	Step2: SES	-.630	.509	-.203	.174*	.137	.048
	SCS-AV	-.602	.371	-.267			
Total negative affect	*Step 1: SES*	-10.544	2.377	-.547**	.300**	.284	.300*
	Step2: SES	-9.400	2.900	-.488*	.307**	.276	.007
	SCS-AV	-1.472	2.113	-.105			
Catastrophizing	*Step 1: SES*	-1.064	.423	-.348*	.121*	.102	.121*
	Step2: SES	-.628	.506	-.205	.164*	.127	.043
	SCS-AV	-.560	.368	-.252			
Personalizing	*Step 1: SES*	-.506	.412	-.178	.032	.011	.032
	Step2: SES	.066	.483	.023	.117	.078	.056*
	SCS-AV	-.735	.352	-.355*			
Equanimity	*Step 1: SES*	-.268	.374	-.105	.011	-.010	.110
	Step2: SES	.120	.447	.047	.060	.018	.049
	SCS-AV	-.500	.326	-.269			
I tried to be kind to myself	*Step 1: SES*	1.007	.449	.314*	.098*	.079	.098*
	Step2: SES	.466	.533	.145	.159*	.121	.060
	SCS-AV	.695	.388	.297			
I tried to make myself feel better	*Step 1: SES*	1.207	.534	.316*	.100*	.080	.100*
	Step2: SES	.725	.643	.190	.133*	.095	.034
	SCS-AV	.619	.469	.222			
I kept the feedback in perspective	*Step 1: SES*	-.163	.412	-.058	.003	-.018	.003
	Step2: SES	-.867	.470	-.310	.137*	.099	.134*
	SCS-AV	.905	.342	.444*			

** Correlation is significant at the .01 level (1-tailed). * Correlation is significant at the .05 level (1-tailed).

The results show that self-compassion predicted unique variance for personalizing thoughts (R^2 = .117, ΔR^2 = .056, p<.05) and one of the reactions: "I kept the feedback in perspective (R^2 = .137, ΔR^2 = .134, p<.05)", above and beyond self-esteem. These findings provide little support for Hypothesis 2 since, with the exception of these two variables, there was no significant correlation among self-compassion with post self-criticism, reactions, thoughts, and emotions after controlling for self-esteem.

3.3.3 Hypothesis 3: Changes Between Variables Before and After Sprint Testing

The third hypothesis predicted that athletes with a higher level of self-compassion should have better sprint performance after receiving and implementing biomechanical feedback. Descriptive statistics for the biomechanical variables are represented in Table 3.6.

Table 3.6

Descriptive Statistics of Biomechanical Variables

Variable		*Range*	*Mean*	*SD*
Time (Seconds)	*1st sprint*	5.52 – 8.74	6.67	0.73
	2nd sprint	5.35 – 7.7	6.40	0.54
	3rd sprint	5.44 – 7.46	6.36	0.53
	4th sprint	5.41 – 7.43	6.32	0.54
	4th-1st sprint (i.e., difference)	0.01 – 2.07	0.40	0.40
Step length (Meters)	*1st sprint*	0.77 – 1.03	0.90	0.06
	2nd sprint	0.83 – 1.09	0.95	0.05
	3rd sprint	0.85 – 1.06	0.95	0.04
	4th sprint	0.79 – 1.09	0.95	0.06
Step frequency (Steps/Minute)	*1st sprint*	93.37 – 145.29	120.33	9.44
	2nd sprint	94.75 – 138.95	118.48	8.43
	3rd sprint	100.81 – 136.37	118.73	8.14
	4th sprint	100.8 – 144.34	119.93	8.37
Front-to-back sway (Degrees)	*1st sprint*	9.66 – 34.02	20.29	5.27
	2nd sprint	11.79 – 33.5	21.69	5.04
	3rd sprint	10.98 – 35.5	21.85	5.09
	4th sprint	9.83 – 33.47	21.62	4.56
Side-to-side sway (Degrees)	*1st sprint*	4.47 – 17.29	9.30	2.95
	2nd sprint	5.60 – 17.70	10.32	2.78
	3rd sprint	4.93 – 20.69	10.94	3.39
	4th sprint	6.05 – 21.4	11.20	3.43
How important is sprinting performance to your sport?		2-12[1]	8.65	2.46
How important is sprinting performance to you?		2-12	9.54	1.91
How important is it to receive biomechanical feedback on your sprinting performance?		5-12	10.04	1.65
How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?		4-12[2]	9.35	2.01
How good or bad did you feel about your sprinting performance today?		4-12	8.38	1.82

1. Scale ranged between 1 and 12 (1 = Not at all important, 12 = Extremely important)
2. Scale ranged between 1 and 12 (1 = Extremely bad, 12 = Extremely good)

In order to measure the importance of sprinting for participants and the athletes' satisfaction after receiving biomechanical feedback, participants were asked to answer to five questions (Appendix G). A one-tailed Pearson correlation analysis was used to explore the relationships between these five questions (Table 3.7).

Table 3.7

Pearson Correlations Exploring the Relations Among Variables Measuring the Importance of Sprint Performance and Athletes' Satisfaction After Receiving and Implementing Feedback. Note: The table only shows the questions that had significant correlations. The answers to the questions in bold were correlated to the answers to the unbolded questions listed beneath them.

Question 1. How important is sprinting performance to your sport?	***r***
Question 2. How important is sprinting performance to you?	.525**
Question 2. How important is sprinting performance to you?	
Question 4. How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?	-.261*
Question 5. How good or bad did you feel about your sprinting performance today?	-.360**
Question 3. How important is it to receive biomechanical feedback on your sprinting performance?	
Question 4. How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?	.377**
Question 4. How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?	
Question 5. How good or bad did you feel about your sprinting performance today?	.662**

** Correlation is significant at the .01 level (1-tailed). * Correlation is significant at the .05 level (1-tailed).

To see if any significant changes occurred in biomechanical variables after receiving and implementing biomechanical feedback, a within-between repeated measure ANOVA was performed. The sprint repetitions and sex were used as within and between subject factors, respectively. The result revealed that there was a significant change in sprint time (F [1.67, 76.78] = 21.61, p<.001), step length (F [2.43, 111.79] = 22.717, p<.001) and front to back sway (F [2.73, 125.64] = 8.099, p<.001) over the sprint repetitions. The pairwise comparison of the means with Bonferroni adjustment ($\alpha = 0.05/6$) showed that these significant changes for all three variables occurred between 1st sprint set with 2nd, 3rd, and 4th sprint sets (Table 3.8). There were no interactions between these biomechanical variables and sex, but there were significant sex effects on sprint time (F [1,46] = 22.94, p<.001), and front to back sway (F [1, 46] = 13.362, p<.05). To account for this, sprint time and sway were expressed as percentages of the respective sex-based gold standards and the analysis was re-run. All other results remained the same, but the sex effects were no longer significant (Figure 4).

Table 3.8

Repeated Measure ANOVA Analysis of Biomechanical Variables.

Note: The mean difference column represents the differences between the means of each biomechanical variable at given sprint repetitions.

Variables	*Sprint Repetitions*		*Mean Difference*	*Std.Error*	*P[a]*
Sprint time	1	2	.263*	.054	.000
		3	.305*	.058	.000
		4	.342*	.066	.000
Step length	1	2	-.049*	.008	.000
		3	-.056*	.009	.000
		4	-.500*	.010	.000
Front to back sway	1	2	-1.367*	.399	.008
		3	-1.516*	.392	.002
		4	-1.290*	.379	.008

* The mean difference is significant at the .05/6 level.

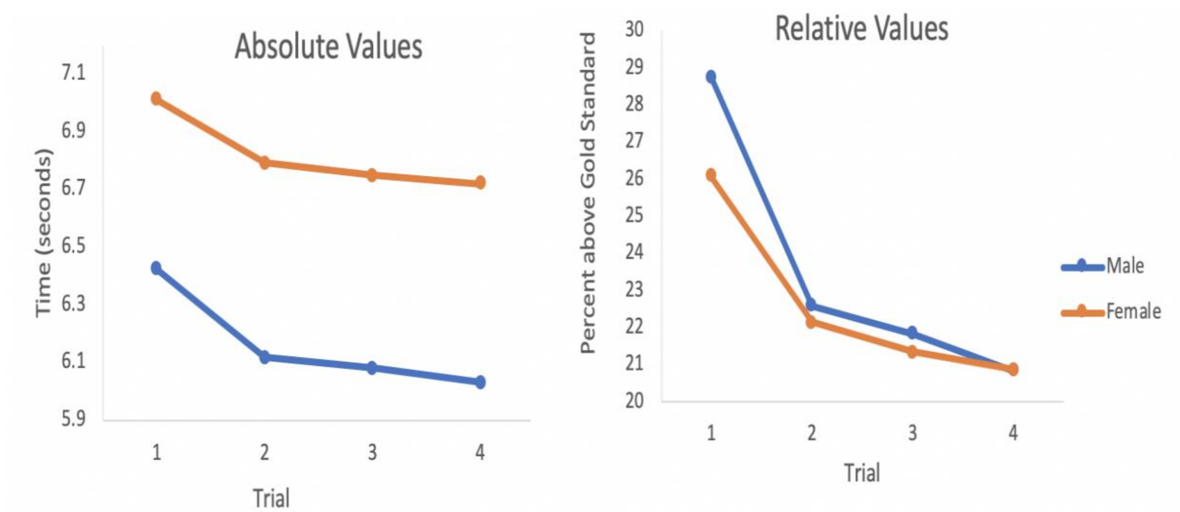

Figure 3.1. Sex effect on sprint time. Left: the original sex-specific means for each sprint time trial. Right: the sex-specific sprint time means expressed as the difference between the subject's sprint time and the gold standard as a percent of the gold standard obtained from the University sprinters for each sprint time trial.

Hypothesis 3 examined if there is any relationship between self-compassion and sprint performance. Based on the above results, since the changes in sprint time, step length, and front to back sway were similar after receiving biomechanical feedback and sprint time is a more tangible and familiar concept, it makes sense to choose the sprint time as the main indicator of sprint performance to test Hypothesis 3. A one-tailed Pearson correlation analysis was used to see if there were any relationships between sprint time and psychological factors measured before and after sprint test. There were no significant correlations between sprint time and self-compassion, self-esteem, baseline self-criticism, and concern over mistakes. The correlations between sprint time and post self-criticism, reactions, thoughts, and emotions after receiving biomechanical feedback are presented in Table 3.9.

Table 3.9

Pearson Correlations After Receiving Feedback

	Sprint Time				
	1st	*2nd*	*3rd*	*4th*	*4th - 1st*
Post self-criticism	.078	.205	.161	.188	.098
Total negative affect	.332*	.283**	.330*	.314*	-.165
Thoughts (1st question)					
- Catastrophizing	-.008	.018	.012	.101	.134
- Personalizing	.229	.136	.067	.065	-.296*
- Equanimity	-.034	-.069	.025	.022	.082
- Humorous	-.366**	.326*	.252*	.206	-.350**
Thoughts (2nd question)					
- I seem to have bigger problems than most people do	.187	.278*	.339**	.372**	.141
- I'm a loser	-.043	-.007	-.009	.066	.149
- This isn't any worse than what lots of other people go through	.110	.094	.104	.066	-.101
- Why do these things always happen to me?	.000	.070	.073	.094	.112
- In comparison to other people, my life is really screwed up	.184	.160	.197	.156	-.112
- Everyone has a bad day now and then	.174	.097	.132	.211	-.030
Reactions (1st question)					
- Behavioral equanimity	-.073	.008	-.060	-.037	.074
Reactions (2nd question)					
- I tried to be kind to myself	.101	.053	.017	.019	-.142
- I tried to make myself feel better	.260*	.192	.126	.117	-*.283**
- I was really hard on myself	.199	.208	.181	.208	-.076
- I kept the feedback in perspective	.030	.015	.007	-.088	-.155
- I tried to do things to take my mind off of the feedback	.343**	.195	.231	.149	-.382**
- I expressed my emotions to let off steam	.181	.078	.076	.052	-.234
- I took steps to fix the problem or made plans to do so	.143	.125	.031	-.055	-.301*
- I sought out the company of others	.273*	.071	.067	.019	-.423**
- I gave myself time to come to terms with it	.359**	.251*	.223	.112	-.452**
How important is sprinting performance to your sport?	-.074	-.080	-.083	-.204	-.124
How important is sprinting performance to you?	-.119	-.300*	-.232	-.321*	-.191
How important is it to receive biomechanical feedback on your sprinting performance?	.077	.117	.109	.130	.029
How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?	-.173	-.044	-.043	.038	.328*
How good or bad did you feel about your sprinting performance today?	-.079	.007	.014	.083	.229

** Correlation is significant at the .01 level (1-tailed). * Correlation is significant at the .05 level (1-tailed).

A moderated regression analysis was used for evaluating the association between the level of self-compassion and sprint performance of athletes after receiving and implementing biomechanical feedback. The interaction between 1st sprint time and self-compassion considered as a moderator between the 1st and 4th sprint time variables. The result was that the interaction did not predict unique variance in sprint performance, thus the level of self-compassion was not a moderator for the change in sprint performance (R^2 = .642, ΔR^2 = .10, p>.05).

In summary, the result of my study did not support Hypothesis 3. The findings show that the sprint performance was significantly improved after receiving biomechanical feedback. Also, although there was a positive correlation between athletes' feelings about the biomechanical feedback and their satisfaction about their sprint performance, there was no relationship between the improvement of sprint performance and the athletes' level of self-compassion.

Chapter 4: Discussion

4.1 Psychological Findings

The purpose of this research was to explore whether self-compassion, self-esteem, concern over mistakes, and self-criticism can predict athletes' response to receiving terminal biomechanical feedback; and precisely whether self-compassion can promote healthy reactions, thoughts, and emotions in athletes after receiving and implementing biomechanical feedback. The results show that athletes with a higher level of self-compassion had higher self-esteem and less concern over mistakes and self-criticism. Also, after receiving biomechanical feedback, athletes with a higher level of self-compassion prior to the sprint trials had less self-critical thoughts following the biomechanical feedback and subsequent sprint trials. Alternatively, although the results of this study provide some support for the effectiveness of self-compassion in promoting healthy reactions, thoughts, and emotions in response to sprint performance-based biomechanical feedback; there is little evidence that self-compassion will make the implementation of the feedback more effective for sprint performance, at least over a short series of sprint trials.

Previous studies have emphasized the positive role of self-compassion in coping with emotionally difficult sport-related experiences (e.g., being responsible for a team failure) (Ferguson et al., 2014; Leary et al., 2007; Mosewich et al., 2013; Reis et al., 2015). Of these, perhaps most relevant to my research is the study conducted by Reis et al. (2015) highlighting the benefits of self-compassion for women athletes meeting difficult challenges in sport. Supporting Reis et al. (2015), my results indicate that athletes with a higher level of self-compassion have healthier feelings, thoughts, and reactions. Specifically, the correlations between self-compassion and emotions (i.e., total negative affect), thoughts (i.e., catastrophizing, personalizing, and equanimity), and reactions (i.e., "I tried to be kind to myself", "I tried to make myself feel better", and "I kept the feedback in perspective") were significant, emphasizing the potential positive effects of self-compassion on the athletes' responses to the challenging sport situations. Alternatively, the correlations between self-compassion and the rest of the items (i.e., humorous thought, behavioral equanimity, etc.) were not significant and contrary to the Reis et al. (2015) findings. In addition, Reis et al. (2015) found that self-compassion remained a significant predictor for most of the emotions, thoughts, and reactions after controlling for self-esteem. In my study, among all the responses that correlated with self-compassion, only for "personalizing thoughts" and one of the reactions (i.e., "I kept the feedback in perspective"), self-compassion was a significant predictor over and beyond self-esteem. This difference between the Reis et al. (2015) results and the results of my study could be due to a number of factors.

The first factor is the different scenarios presented. In Reis et al.'s (2015) study participants were asked to recall 'the worst thing that has happened to you in sport during the past year, that was or was not their fault", and to think about the following hypothetical scenario: "Being responsible for losing an athletic competition for their team". Alternatively, in my study, participants were asked to think about the biomechanical feedback on their sprinting performance and rate their emotions, thoughts, and reactions in response to that specific feedback. The scenarios presented in Reis et al. (2015) were highly negative (i.e., recalling and/or being responsible for a sports failure) and might create more emotional challenges for athletes to deal with than receiving biomechanical feedback presents. Performance failures are often accompanied by tendencies to self-criticism and judgment (Ferguson et al., 2014; Gilbert & Irons, 2004, Mosewich et al., 2013). Alternatively, Ceccarelli et al. (2019) showed that self-compassion can predict maladaptive thoughts and negative affect regarding a recalled sports failure, in addition to and promoting psychological and physiological responses in athletes. Leary et al. (2007) also showed the significant role of self-compassion in attenuating negative responses to emotionally difficult events, such as a sports failure, and further evidence suggests self-compassion interventions as an important resource to counter self-criticism and concern over mistakes (Mosewich, 2013; Neff, 2007; Neff, 2003a). Therefore, emphasizing the context of performance failure may reinforce the importance of using self-compassion as a coping mechanism in Reis et al.'s (2015) study and result in a more significant role of self-compassion compared to my study. The athlete's response toward performance-related feedback presented in my study might not be as emotionally challenging as a sports failure represented by Reis et al. (2015). In my study the athletes were asked: "How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today?". The result suggested that the athletes felt more positive than negative about the feedback (M = 9.35, SD = 2.01, *Possible Range* = 1 - 12). While, in Reis et al. (2015) participants rated "how bad the sports event was" on a scale of 1

(“Not at all”) to 6 (“Extremely”). With a mean of 4.12 (*SD* = 1.15) participants felt more negative in Reis et al.’s (2015) study. Although, the feedback provided in my study might not be as emotional as Reis et al. (2015), nevertheless it was important for athletes to receive the biomechanical feedback on their sprint performance (*M* = 10.04, *SD* = 1.65, *Possible Range* = 1 - 12).

Another reason for the difference could be due to the use of a self-compassion induction in Reis et al. (2015). They asked participants to complete three prompts referring to the three main components of self-compassion (i.e., self-kindness, common humanity, mindfulness). Completing the prompts might have directed the participants towards a more self-compassion mindset. Alternatively, in my study, other than potentially by completing the self-compassion measure at the outset, participants had no indication about the type of questions they were going to be asked after sprinting performance. The participants were also not required to focus on their emotions, thoughts, and reactions “during” the experience of their sprint performance (i.e., they only did so after all trials were completed). Previous studies show the significant influence of attentional focus on sports performance (Beilock et al., 2002; Castaneda & Gray, 2007; Wulf, 2007a). However, in my study here were no explicit attempts to have the athletes have a conscious focus on any specific psychological response to the feedback that they were provided. This is both a strength and a weakness in that, on one hand, we were able to measure athletes’ responses to biomechanical feedback with little response bias; however, on the other hand, this makes it more difficult to direct the athletes’ attention specifically to questions we were most interested in related to how they were interpreting and using the feedback.

Another possibility for the difference in results could be due to the differences between the amount of time the participants in this study had to deal with their emotions, thoughts, and reactions after receiving feedback, as compared to Reis et al. (2015). In my study, participants received biomechanical feedback right after each sprint set, and they had only three minutes (i.e., the rest time between each set) to review and think about feedback, as well as potentially to identify a plan as to how they might try to implement the feedback in their next sprint set. This short amount of time for the whole process of receiving and implementing feedback could have influenced the chance of negative emotions, thoughts, and reactions emerging, as well corresponding coping strategies, compared to Reis et al.’s (2015) participants who were recalling a situation that might happened in the less immediate past. In support of this hypothesis, the results of my study indicate that self-compassion is related to “personalizing thoughts” above and beyond self-esteem. Personalizing thoughts are measured based on two thoughts: “I am such a loser”, and “I should have expected this would happen”. Compared to catastrophic, humorous, and equanimity thoughts, which are more related to individuals’ thoughts regarding immediate performance (e.g., “This is embarrassing”), personalizing thoughts are more related to individuals’ pre-judgment of their sports performance. Therefore, measuring psychological responses to a sports-specific event a longer time after the performance might increase the chance of implementing coping strategies such as self-compassion.

Finally, athletes might be so used to receiving performance-related feedback- not specifically biomechanical feedback- over the years, and perhaps they have a set of coping skills already to deal with difficult feedback (i.e., maybe they don’t need to utilize self-compassion). This hypothesis might also support why self-esteem was sufficient for predicting responses to the feedback in my study, in contrast to Reis et al.’s (2015) study, who found self-compassion remained significant after controlling for self-esteem. Maybe receiving and implementing biomechanical feedback is not a situation in which self-compassion is essential; instead, it might be one of a number of potentially effective coping skills/options that athletes have available.

Supporting previous studies (e.g., Gilbert & Procter, 2006; Mosewich et al., 2013; Neff., 2003a), the findings of my study indicate negative correlations among self-compassion and self-esteem with self-criticism (both baseline and post running trials) and concern over mistakes. Although, the baseline self-criticism and concern over mistakes positively predicted post self-criticism and emotions (i.e., total negative affect) after receiving biomechanical feedback, the relationships were not significant for the thoughts and reactions. Only for catastrophizing thoughts and one of the reactions items (“I tried to be kind to myself”), was baseline self-criticism a significant predictor. A possible reason could be the athletes’ high level of self-compassion. Self-compassion as a coping strategy can reduce the level of self-criticism and concern over mistake (Gilbert & procter, 2006; Mosewich et al., 2013), and, as Mosewich et al. (2013) showed, self-compassion can help women athletes in coping with both self-criticism and concern over mistakes. Perhaps the relatively high level of self-compassion in this sample actually made it less likely that they would experience the biomechanical feedback negatively, and experience less self-criticism and concern over mistakes to begin with, since self-compassion can change maladaptive thoughts, feelings, and behaviors by fostering more positive self- perceptions of the situation (Neff, 2003a). In other words, is seems possible that the athletes simply did not experience the biomechanical feedback as emotionally difficult and with a high degree of self-criticism and concern over mistakes, because they were already viewing the feedback from a more self-compassionate lens.

4.2 Biomechanical Findings

An additional finding of interest in my study is that receiving biomechanical feedback for the first time (i.e., after 1st sprint set) result in a significant improvement in the next sprint performance (i.e., 2nd sprint set). There is a wide range of studies that show the effectiveness of biomechanical feedback on performance enhancement (Broker et al., 1993; Mauger et al., 2009; Mendoza & Schollhorn, 1993; Sanderson & Cavanagh, 1990), although, in most of the studies, multiple sets of biomechanical feedback were provided. To the best of my knowledge, there are only a few studies that investigate the performance improvement after each time the biomechanical feedback was delivered. The closest study to my research is Mauger et al. (2009), who looked into the performance feedback for improvement of 4-km cycling performance. Similar to my study, Mauger et al. (2009) found that immediately after receiving feedback, performance improved. However, unlike Mauger et al.'s (2009) finding that cycling performance continued to be different across the second and third trials, while in my study, there were no significant differences between second, third, and fourth sprint performances after receiving biomechanical feedback. A potential reason could be due to the difference in the way the feedback was presented in both studies. In my study, participants received feedback based on their most recent performance, while in Mauger et al. (2009), the feedback was based on the baseline time trial. This difference might affect whether the feedback is intended positive, negative, or neutral. In Mauger et al.'s (2009) study, athletes received positive feedback as long as their performance was better than their baseline time trial. While, in my study, athletes received positive feedback only if they successfully improved their sprint performance compared to the gold standard. It means that, regardless of any improvement than their baseline trial (i.e., 1st trial), they received neutral or negative feedback, if they maintained or slightly decreased their performance than their last trial.

An alternative reason for observing changes only after the first sprint set could be due to the lack of appropriate interpretation of biomechanical feedback. Preatoni et al. (2013) highlighted the importance of the translation of biomechanical feedback information into understandable and applicable information for coaches and athletes. In addition, coaches can use the biomechanical feedback to provide accurate perceptual information (e.g., motor experiences) and guide athletes towards optimal performance (Smith & Loschner, 2002).

However, in my study, there was no prescriptive feedback (i.e., error correction) provided by the coach based on the biomechanical feedback. This might limit the depth of information that athletes could gain from biomechanical feedback and, therefore, decrease the effectiveness of implementing the biomechanical feedback by athletes.

Another possible explanation for the performance improvement observed in my study after the first sprint set could be the practice effect due to familiarization with test protocols and equipment (i.e., inertial sensors and timing gate chip) rather than feedback effects. To see if the familiarization could be responsible for this performance improvement, a secondary experiment with the same inclusion criteria and partial changes to the study design was performed on ten athletes that were not a part of the original study cohort. The result of a repeated measure ANOVA analysis revealed that there was no significant effect on sprint performance between 1^{st} and 2^{nd} trials (see Appendix J for more details). These data suggest that the performance improvement seen between the first and second trials in the main study may not have been the result of familiarization, but the results were somewhat inconclusive as feedback did not change performance at all in the secondary experiment.

4.3 Feedback

In this study, a combination of KR and KP biomechanical feedback was provided to athletes at the end of each trial. The athletes received KR feedback on sprint time and KP feedback on step length, step frequency, and trunk sway. The results show that for KR feedback (sprint time), there was a significant improvement between 1^{st} and 2^{nd} trials, but this significant change was not present in the next trials. The potential reason for this inconsistency in the results could be due to the optimal frequency of providing KR feedback to athletes. Previous studies show that the less frequent KR feedback (i.e., having some no-feedback trials) can improve the learning of motor skills more efficiently than frequent feedback (Salmoni et al., 1984; Schmidt, 1991). Salmoni et al. (1984) showed that despite the strong guiding effect of frequent KR feedback, it causes dependency on the feedback and prevents learners from using intrinsic feedback processing and error detection.

Additionally, the effects of KP feedback provided at the end of each trial were not consistent across all of the measured variables. There were no significant changes in step frequency and side-to-side sway, while step length and front to back sway significantly changed between the 1^{st} and 2^{nd} trials. This might happen due to the complexity of understanding how to adjust step frequency and side-to-side sway, rather than the other two variables. In my study, participants may not have been familiar with these kinematic variables. Therefore, providing prescriptive feedback may facilitate the participants' interpretations of biomechanical feedback received on their sprint performance. For example, athletes who had more side to side trunk sway than gold standard may know that they should decrease their trunk sway to decrease their sprint time based on the information provided in tutorial video, but they may not be familiar with the mechanisms underlying side to side trunk sway and the ways they can adjust it. Also, a higher frequency of the KP feedback can provide better guidance during skill acquisition, especially for novices (Winstein & Schmidt, 1990; Wulf et al., 1994; Wulf & Shea, 2002). Also, studies show the effectiveness of frequent KP feedback on complex movements (i.e., sports-specific skills requiring whole-body movements with many degrees of freedom) (Eriksson et al., 2011; Wulf et al., 1998). Wulf et al. (1998) showed the positive effects of frequent feedback on motor skill learning. They provided KP feedback with two different frequencies (100% and 50%) about the force onset and the results show that participants who received concurrent KP with 100% feedback frequency about the force onset of the feet during ski-simulator training had more performance improvement than reduced 50% frequency of feedback.

4.4 Self-Compassion and Performance

Having higher levels of self-compassion did not seem to help athletes to perform better after receiving feedback, based on the finding that not only was there was no relationship between the level of self-compassion and sprint performance and that self-compassion was not a moderator of change in sprint performance across trials. Alternatively, self-compassion was related to factors that were associated with performance that might improve sprint performance over a longer period of time. For example, self-compassion was found to be a unique predictor of personalizing thoughts; while, at the same time, personalizing thoughts was negatively related to sprint performance. Similarly, all four sprint times were positively related to negative affect, and negative affect was negatively correlated with self-compassion.

Based on cognitive-motivational theory, the intensity of emotional experience depends on the importance of the goal and the performance-goal discrepancy (Lazarus, 1991; Lazarus, 1993; Locke & Latham, 1990). The degree to which the goal is important to individuals affects the intensity of emotions they will experience. In this study, participants rated "How important is sprinting performance to you?" and "How important is it to receive biomechanical feedback on your sprinting performance?" on a scale of 1 to 12 (1 = Not at all important, 12 = Extremely important). The results show that both sprint performance (M = 9.54, SD = 1.92) and receiving biomechanical feedback on sprint performance (M = 10.04, SD = 1.65) were important to athletes. By increasing the importance of goal, more emotions are expected to emerge (Graham et al., 2002; Lazarus, 1991).

Also, studies show that performance-goal discrepancy is associated with performance satisfaction and feelings of success (Gaudreau et al., 2002; Graham et al., 2002). Lower levels of performance-goal discrepancy will result in positive emotions, while higher levels of performance-goal discrepancy will create negative emotions. In my study, participants received feedback about their sprint performance after each sprint set and were asked to increase their performance to match the gold standards. Using gold standards as performance goal may increase the performance-goal discrepancy in athletes, since almost none of the participants could meet those standards. Therefore, the high levels of goal importance and possible performance-goal discrepancy in this study likely enhanced the chances of athletes experiencing emotional responses to receiving and implementing biomechanical feedback.

An analysis of the importance of receiving feedback and the athletes' satisfaction after receiving biomechanical feedback revealed that participants' satisfaction with the biomechanical feedback was positively related to the degree to which they were satisfied with their sprint performance. This means that, on one hand, feeling good or bad about the biomechanical feedback was directly related to feeling good or bad about sprint performance. On the other hand, the results show that participants' satisfaction with biomechanical feedback was significantly associated with their sprint performance. In my study, athletes could receive positive (i.e., indicating better performance), negative (i.e., indicating worse performance), or neutral (i.e., indicating no change) feedback. The sprint performance was decreased in participants who felt bad about the feedback they received, while participants who felt good about the feedback had better sprint performance. Therefore, this finding suggests that personal satisfaction is significantly related to better sprint performance. Although, the athletes' satisfaction in my study was not related with the level of self-compassion, Neff and Vonk (2009) found that performance satisfaction can decrease due to maladaptive coping strategies; and based on Neff (2003b), self-compassion could help athletes to be more open to feedback and accept failures as a common human experience.

Moreover, the importance of sprint performance for participants seemed to be related to the degree in which sprinting was important in their sport. For example, athletes who were involved in sports in which sprinting plays a more important role in their sports performance (e.g., soccer) appeared to care more about their sprint performance. Also, there was a negative correlation between the importance of sprint performance and athletes' satisfaction with their sprint performance. Athletes who care more about sprint performance felt worse about the biomechanical feedback they received on their sprinting performance. Although the results of my study showed no relationship between self-compassion and the athletes' feelings about biomechanical feedback they received, Jopling (2000) showed that mindfulness, as one of the main components of self-compassion, can decrease self-criticism by having a nonjudgmental approach towards negative experiences.

4.5 Limitations

This research was designed specifically to provide objective feedback without a person, such as a coach, to interpret the biomechanical feedback for the participant in order to avoid prescriptive feedback and make sure all the athletes received the same information. This provided enough confidence that all the results achieved were due to the athletes' personal responses to the feedback, rather than a different delivery of feedback by a coach. Although the importance and benefits of a coach's feedback on athletic performance are proven (Magill, 2011; Mendoza & Schollhorn, 1993; Smith & Loschner, 2002), it is hard to control for the variance of coach's interpretations of feedback among the athletes. Instead, a tutorial video was presented to explain the feedback and the way athletes can use each feedback to improve their sprint performance. Although using objective feedback was beneficial to the validity of the results, it limited the amount of information that athletes could receive, and correspondingly likely weakened the efficacy of the feedback (Van Vliet & Wulf, 2006). Also, the athletes' experience regarding receiving and implementing biomechanical feedback was not controlled in my study. Some athletes might have had more experience than others, resulting in more improvement in their performance. Perhaps the presence of a coach could help athletes' interpretation of the biomechanical feedback and provide more guidance regarding performance's modifications. Consequently, it may impact on the athletes' responses to the feedback by increasing the effectiveness of feedback on sprint performance.

Testing environment, including the presence of others, can influence sports performance. Studies show that sports performance could increase or decrease in the presence of others based on athletes' individual personality (Geisler & Leith, 1997; Schrauger, 1972). One of the limitations of this study was controlling the testing environment. All the data from the main participants were collected on a public indoor running track at the Physical Activity

Complex at the University of Saskatchewan. Only one wing of the track was allocated to our data collection, while the other parts of the track were accessible for public. In order to control potential distraction due presence of other people, testing hours were chosen in a way to minimize the effects of external factors such as number of non-participants present at the location, audience feedback, noise, etc. Participants were not permitted to bring someone to accompany them, and only participants were allowed to enter the test site. Also, the entrance/exit doors were far away from the testing location and out of sight of participants. However, despite my best attempts, the testing environment did vary to some degree across participants, particularly the presence of others.

Another limitation of this research might be the participants' baseline level of self-compassion. One of the main objectives of this study was to explore whether athletes with a higher level of self-compassion had better sprint performance after receiving feedback. Descriptive analysis revealed that athletes who participated in this study had a higher level of self-compassion (M = 3.47, SD = 0.55) in comparison to Reis et al. (2015) (M = 3.10, SD = 0.58) and Leary et al. (2007) (Study 1: M = 3.15, SD = 0.63; Study 2: M = 3.03, SD = 0.58; Study 5: M = 3.08, SD = 0.58). Recruiting athletes with different levels of self-compassion might be beneficial in examining the responses to the feedback in athletes with different baseline levels of self-compassion; as this would also likely result in a higher variety in the level of self-esteem, self-criticism, and concern over mistakes, due to the well-established correlations between these psychological factors (Mosewich, 2013; Reis et al., 2015). Perhaps, having a larger sample size and grouping of athletes with different levels of self-compassion (i.e., low, moderate, high) could increase the possibility to observe more variety in the negative emotions, thoughts, and reactions in athletes' responses to the feedback and, consequently, the effectiveness of self-compassion as a coping strategy.

In order to measure athletes' responses to the feedback, pre-existing questionnaires such as the self-criticism scale by Gilbert and Procter (2006), and hypothetical and recalled scenarios by Leary et al. (2007) were used. On the one hand, using pre-existing questionnaires was beneficial, because it made my study results comparable with previous studies. Since there were no specific measures for running, I had to adapt the pre-existing questionnaires, and adjust them based on my research's objectives. One of the reasons that questionnaires needed to be adapted was that the questionnaires presented in Leary et al.'s (2007) study were referred to the hypothetical or recalled situations, while in my study, the objective was to measure the participant's responses to the biomechanical feedback on their sprint performance. Also, there were some extremely negative items (e.g., “I wish I could die”) that were not applicable in my study and replaced with sentences that were more related to negative reactions, thoughts and emotions after receiving and implementing feedback (e.g., “This is embarrassing”). Although using the sport version of some questionnaires (e.g., the athletic version of self-compassion scale) and rewording others by using sport specific language, may have aligned the questionnaires closer to the study objectives, there were a few items that still might not have been applicable. For example, a few items in the post self-criticism questionnaire were asking about the amount of time that athletes spent dealing with self-critical thoughts (e.g., “How often did you have self-critical thoughts?”, or “How long did your self-critical last?”). In the current study, athletes had only three minutes of rest between each trial and completed the post questionnaires immediately after finishing the sprint trials. Therefore, they may not have had enough time to deal with their self-critical thoughts and the answers they provided may not represent the actual level of their self-criticism. Moreover, using the sport version of questionnaires may not guarantee higher quality of assessment. For example, in this study instead of the original self-compassion scale, the athlete version of self-compassion (SCS-AV) was used. Although some validity evidence for this scale was provided by Killham et al. (2018), there is not much psychometric information to show whether the athlete version is more or less useful than the original self-compassion scale. Besides, to the best of my knowledge there is no evidence to prove that the athlete version may be more related and relevant to self-compassion reactions to biomechanical feedback specifically.

To reach the desired sample size, athletes from multiple team sports (i.e., soccer, basketball, volleyball, football, and hockey) were recruited. Consequently, choosing a general skill that would be applicable in all of the mentioned sports (i.e., sprinting) and avoiding sport-specific skills was an important research decision. However, a limitation is that the general skills (i.e., sprinting) might be more relevant to some sports and athletes than others. Unfortunately, there was not a lot of representation across some sports in my sample, making it hard to have insight into this limitation. Although, receiving biomechanical feedback on sprinting performance was important to most of the participants, the result of my study emphasized the positive relationship between the importance of receiving biomechanical feedback on sprinting performance and the degree which sprinting skill was important to athletes’ sport. Therefore, receiving feedback regarding a sport-specific skill might change the athletes’ responses to the feedback.

4.6 Future Directions

There are several design modalities that can be taken into consideration to develop more effective feedback for athletes. The participants in my study were not track and field athletes and probably not used to receiving feedback on their sprint performance. Also, some of the biomechanical content of the feedback might be new to them. Therefore, they might benefit from more frequent feedback. Studies show the effectiveness of higher rate of feedback on performance improvement in inexperienced athletes (Eriksson et al., 2011; Wulf et al., 1998). On the other hand, a high rate of augmented feedback can provide better guidance for athletes especially for complex motor tasks (Wulf & Shea, 2002; Wolpert et al., 2011). Therefore, conducting a study with a more frequent feedback design on a sport-specific skill may lead to different results.

In this study, the coach's feedback was avoided to control for the consistency of the amount and the content of the feedback for each athlete. However, a combination of coach's feedback and tutorial videos can provide better guidance for athletes, and hence result in either significant improvement or failure in performance following each trial. As was discussed earlier, Mauger et al. (2009) showed the effects of coach's feedback on performance improvement after each trial, while in my study the feedback was only effective on the second performance (i.e., right after receiving feedback for the first time), and no significant changes were observed on the third and fourth sprint attempt. Thus, it would be helpful for future research to use both descriptive and prescriptive feedback.

The emotional reactions of individuals during sport performance could change across different time points, especially in stressful situations (Cerin et al., 2000; Crocker et al., 1998). The duration of emotional experience could vary from a couple seconds up to hours or more (Frijda et al. 1991; Verduyn et al. 2009). In addition, some emotions are more persistent (e.g., sadness) than others that tend to fade away relatively quickly (e.g., irritation, some fear; Scherer & Wallbott 1994; Verduyn et al. 2009; Verduyn & Brans 2012). In my study the athletes' emotions were measured at the end of the session, after performing all four sprint sets. It is possible that measuring emotions at the end of the session, rather than right after each set, resulted in missing more fleeting emotions that remain only for a shorter period of time as part of the measurement. Future studies could consider assessing discrete emotions after each trial, rather than simply including only a more general measure of emotion after all trials are completed, which could provide more information on the emotional experiences of athletes receiving biomechanical feedback on their performance.

Furthermore, in this study, a combination of basic emotions (e.g., anger, fear, sadness) and self-conscious emotions (e.g., shame, guilt) were part of the measure athletes' emotions in response to the biomechanical feedback. However, in order to avoid participant burden, these were part of a general negative affect measure, with the intent to see if receiving feedback was related to negative emotions. Future studies might measure the descrete emotions, rather than general affect, including both negative and positive emotions (e.g., pride, joy, happiness) that might be relevant to receiving biomechanical feedback. Also, focusing more on the self-conscious emotions (e.g., shame, guilt, pride) in particular might be helpful. Self-conscious emotions can be responsible for negative affect after receiving negative feedback and the discrepancy between a current self-state and a goal state (Tracy & Robins, 2004). Compared to the basic emotions, self-conscious emotions are important contributors in emotional responses to the feedback and achieving performance goals (Rebar & Conroy, 2013).

In this study, the overall self-compassion scores were used to explore changes in sprint performance and the athletes' responses to the feedback. Although the validity and reliability of the overall self-compassion score is well documented (Neff, 2003a; Neff, 2016), analyzing the self-compassion subscales might be another approach to explore the associations among self-compassion and healthier emotions, thoughts, and reactions in response to biomechanical feedback. Previous studies show the effectiveness of specific subscales, such as common humanity and mindfulness, on decreasing self-criticism (Jopling, 2000) and openness to the feedback (Neff, 2003b). It is reasonable to study whether or not the subscales of self-compassion would be more strongly related to athletes' responses to feedback than a general measure of self-compassion.

Likewise, to explore the importance of self-compassion as a coping mechanism beyond self-esteem, further research is needed to study the effects of using self-compassion inductions on sport performances and athletes' responses to biomechanical feedback. Self-compassion training results in improving the positive subscales (i.e., self-kindness, common humanity, and mindfulness) and decreasing negative subscales (i.e., self-judgment, isolation, over identification) of self-compassion (Neff, 2016). In this study however, due to time limitations, athletes did not receive any self-compassion inductions, and they had no prior information about the nature of the questionnaires. Practicing self-compassion prompts could increase athletes' awareness of their emotions, thoughts, and reactions, and, as a result of being more compassionate, they may improve their responses to biomechanical feedback. In Leary et al. (2007) and Reis et al.'s (2015) studies, participants were aware of the scenarios in advance and took advantage of practicing the three main components of self-compassion during the self-compassion induction. This helped participants to deal with the scenarios in a self-compassionate manner. Therefore, future studies may benefit from using a self-compassion induction to reinforce the role of self-compassion as a coping mechanism in a sport's difficult situations.

4.7 Conclusion

One of the unique findings of my study is that self-compassion and self-esteem seem to be equally effective in helping athletes respond effectively to biomechanical feedback. The results of my study show that self-compassion and self-esteem were negatively correlated to self-criticism after receiving biomechanical feedback. Also, they both can predict emotions, thoughts, and reactions of athletes after receiving biomechanical feedback, but inconsistent with previous studies, after controlling for self-esteem, self-compassion did not remain a significant predictor of most athletes' responses to the biomechanical feedback. The only exceptions were personalizing thoughts and one of the reactions (i.e., "I kept the feedback in perspective"), which self-compassion predicted unique variance above and beyond self-esteem.

Regarding the effectiveness of biomechanical feedback on the sprint performance, the result show that the first presentation of biomechanical feedback significantly improved the sprint time, step length and front to back sway. Although, this improvement was maintained across subsequent attempt, for all the biomechanical variables, there was no significant change in performance between the 2nd, 3rd, and 4th sprint sets. There is a possibility that providing more guidance (i.e., coach's feedback) or/and higher frequency of feedback might increase the effectiveness of the feedback.

Although the level of self-compassion was not directly associated with sprint performance, the analysis of the importance of receiving biomechanical feedback and the athlete's satisfaction supported the potential positive effects of higher levels of self-compassion on sprint performance. My study provides limited support for the importance of self-compassion as a coping mechanism over and beyond self-esteem. Future research is needed to investigate the effects of different modes of biomechanical feedback on general and sports-specific tasks to increase the effectiveness of receiving and implementing biomechanical feedback on sports performance. Also, continued exploration of self-compassion and athletes' responses through the change of attentional focus (e.g., using self-compassion inductions) or a variety of more emotionally challenging scenarios.

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Appendices

Appendix A: Demographic Questionnaire

Sex:________ Age: __________________ Height:________________ Weight:__

Date of Birth (month/date/year):

Sociocultural Information:

How would you describe yourself? You may mark more than one, if applicable.

___ Indigenous ___ Latin American
___ Arab ___ South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc.)
___ Black ___ Southeast Asian (e.g., Vietnamese, Cambodian, Malaysian, Laotian, etc.)
___ Chinese ___ West Asian (e.g., Iranian, Afghan, etc.)
___ Filipino ___ White
___ Japanese ___ Other – Specify______________________________________

Medical History

Have you ever been diagnosed with or treated for any musculoskeletal injuries (e.g., hip, knee or ankle injuries) or health conditions (e.g., postural imbalance, neurological impairments) that may impair your ability to perform maximal effort sprinting? YES ○ NO ○

If yes, please Specify____

Sports Participation and Training History

Please indicate the levels of sport competition you have competed at IN THE LAST 12 MONTHS. Also indicate the sport(s) that each level is applicable to.

Club/Community Sport:

LEVEL	SPORT(S)
Recreational (Competing in intramurals or in a recreational league)	
Local (Competing against athletes from your city/town)	
Provincial (Competing against athletes from around the province)	
Regional (Competing against athletes from the Western provinces)	
National (Competing at a National Championship)	
Elite for Age (Competing at an international level against athletes of the same age group)	
International (Competing for your country of Citizenship at an international level)	

Other (please specify) ____________________________

During the <u>PAST WEEK</u>, how many times did you play an active team sport, such as soccer, football, volleyball, hockey, and basketball? *(circle one)*

0	1	2	3
not at all			*5 or more times*

Appendix B: Self-Compassion Scale

Please read each statement carefully before answering. To the left of each item, indicate how often you behave in the stated manner, using the following scale:

Almost never				**Almost always**
1	**2**	**3**	**4**	**5**

_____ 1. I'm disapproving and judgmental about my own flaws and inadequacies as an athlete.

_____ 2. When I'm feeling down as an athlete, I tend to obsess and fixate on everything that's wrong in my sport.

_____ 3. When things are going badly for me in my sport, I see the difficulties as part of sport that all athletes goes through.

_____ 4. When I think about my inadequacies in sport, it tends to make me feel more separate and cut off from the rest of the world.

_____ 5. I try to be loving towards myself when I'm feeling emotional pain in sport.

_____ 6. When I fail at something important to me in sport, I become consumed by feelings of inadequacy.

_____ 7. When I'm down and out, I remind myself that there are lots of other athletes in the world feeling like I am.

_____ 8. When times are really difficult in sport, I tend to be tough on myself.

_____ 9. When something upsets me in sport, I try to keep my emotions in balance.

_____ 10. When I feel inadequate in sport, I try to remind myself that feelings of inadequacy are shared by most athletes.

_____ 11. I'm intolerant and impatient towards those aspects of my athletic personality I don't like.

_____ 12. When I'm going through a very hard time in sport, I give myself the caring and tenderness I need.

_____ 13. When I’m feeling down, I tend to feel like most other athletes are probably happier than I am.

_____ 14. When something painful happens to me in sport, I try to take a balanced view of the situation.

_____ 15. I try to see my failings in sport as part of the shared athletic condition.

_____ 16. When I see aspects of myself as an athlete that I don’t like, I get down on myself.

_____ 17. When I fail at something in my sport, I try to keep things in perspective.

_____ 18. When I’m really struggling, I tend to feel like other athletes must be having an easier time of it.

_____ 19. I’m kind to myself when I’m experiencing suffering in sport.

_____ 20. When something upsets me in sport, I get carried away with my feelings.

_____ 21. I can be a bit cold-hearted towards myself when I’m experiencing suffering in sport.

_____ 22. When I’m feeling down in my sport, I try to approach my feelings with curiosity and openness.

_____ 23. I’m tolerant of my own flaws and inadequacies in sport.

_____ 24. When something painful happens in my sport, I tend to blow the incident out of proportion.

_____ 25. When I fail at something in my sport, I tend to feel alone in my failure.

_____ 26. I try to be understanding and patient towards those aspects of my athletic personality I don’t like.

Appendix C: Rosenberg Self-Esteem Scale

Instructions: Below is a list of statements dealing with your general feelings about yourself. If you strongly agree, circle **SA**. If you agree with the statement, circle **A**. If you disagree, circle **D**. If you strongly disagree, circle **SD**.

1. On the whole, I am satisfied with myself.	SA	A	D	SD
2. At times, I think I am no good at all.	SA	A	D	SD
3. I feel that I have a number of good qualities.	SA	A	D	SD
4. I am able to do things as well as most other people.	SA	A	D	SD
5. I feel I do not have much to be proud of.	SA	A	D	SD
6. I certainly feel useless at times.	SA	A	D	SD
7. I feel that I'm a person of worth, at least on an equal plane with others.	SA	A	D	SD
8. I wish I could have more respect for myself.	SA	A	D	SD
9. All in all, I am inclined to feel that I am a failure.	SA	A	D	SD
10. I take a positive attitude toward myself.	SA	A	D	SD

Appendix D: Sport-Multidimensional Perfectionism Scale-2

To what extent do you agree or disagree with the following statements?	**Strongly Disagree**	**Disagree**	**Neither Agree Nor Disagree**	**Agree**	**Strongly Agree**
1. Even if I fail slightly in competition, for me, it is as bad as being a complete failure.	1	2	3	4	5
2. If I fail in competition, I feel like a failure as a person.	1	2	3	4	5
3. The fewer mistakes I make in competition, the more people will like me.	1	2	3	4	5
4. I should be upset if I make a mistake in competition.	1	2	3	4	5
5. If a team-mate or opponent (who plays a similar position to me) plays better than me during competition, then I feel like I failed to some degree.	1	2	3	4	5
6. If I do not do well all the time in competition, I feel that people will not respect me as an athlete.	1	2	3	4	5
7. People will probably think less of me if I make mistakes in competition.	1	2	3	4	5
8. If I play well but only make one obvious mistakes in the entire game, I still feel disappointed with my performance.	1	2	3	4	5

Appendix E: Baseline Self-Criticism

Thinking back over the week? (please circle on each):

(a) How often did you have self-critical thoughts?
Had none 1 2 3 4 5 6 7 8 9 10 A lot of the time

(b) How powerful were your self-critical thoughts?

Not at all 1 2 3 4 5 6 7 8 9 10 Very powerful

(c) How intrusive were your self-critical thoughts?
Not at all 1 2 3 4 5 6 7 8 9 10 Very intrusive

(d) How long did your self-critical thoughts last?
Fleetingly 1 2 3 4 5 6 7 8 9 10 Most of the day

(e) How distressed were you by your self-critical thoughts?
Not at all 1 2 3 4 5 6 7 8 9 10 Very distressed

(f) How angry/hostile were your self-critical thoughts?
Not at all 1 2 3 4 5 6 7 8 9 10 Very harassing

(g) How easy was it to distract yourself from your self-critical thoughts?
Not at all easy 1 2 3 4 5 6 7 8 9 10 Very easy

Appendix F: Video Transcript

Hello and thank you for participating in this research study.

You will be running several 40-meter sprints, while wearing sensors. We will then give you feedback on how to run, based on the data we receive from the sensors. This short video will help explain the feedback information that we will provide you.

There are several things that someone has to consider in order to have a fast sprint. One of the most basic factors that determine how fast you can run is how you go from one foot to the next, which is called a 'step'. How fast you sprint is determined by two main factors:

- Step length: how far forward you travel with each step
- Step time: the amount of time it takes you to take a step

Step length is a distance and it is directly related to one's height, as taller people take larger steps. Therefore, we measure your step length as a multiple of your height. This allows us to compare you to other people who might be taller or shorter than you. Step time, on the other hand is known as cadence. We use the number of steps per minute as a measure of cadence. Therefore, a longer stride length equals a higher cadence, hence leading to a faster run.

The next information that we will be giving you after your sprint is your amount of body sway. We will show you how much sway you had in the side to side direction and in the front to back direction. If you have either too much sway or too little sway, this will affect how fast you sprint. After you finish the sprint, the screen will show the following:

The red bars and numbers are the information from your sprint, while the green bars indicate the information gathered from expert sprinters who ran the same 40 meters sprint. You should try to match the information given in the green bars. At the top of the screen you will find the run time. The next set of bars would be the step length, cadence, and the side to side and front to back sway. For the sway, the red arc shows how much you swayed, while the green arc shows how much the expert sprinters swayed. Again, you can use this information to try to improve your next sprint.

Thank you and please let the researcher know if you have any questions. Good luck!

Appendix G: The Importance of Sprinting Performance

How important is sprinting performance to your sport? Please respond between 1 and 12 (1 = Not at all important, 12 = Extremely important).

Indicate your rating here: _____

How important is sprinting performance to you? Please respond between 1 and 12 (1 = Not at all important, 12 = Extremely important).

Indicate your rating here: _____

How important is it to receive biomechanical feedback on your sprinting performance? Please respond between 1 and 12 (1 = Not at all important, 12 = Extremely important).

Indicate your rating here: _____

How good or bad did you feel about the biomechanical feedback on your sprinting performance provided today? Please respond between 1 and 12 (1 = Extremely bad, 12 = Extremely good).

Indicate your rating here: _____

How good or bad did you feel about your sprinting performance today? Please respond between 1 and 12 (1 = Extremely bad, 12 = Extremely good).

Indicate your rating here: _____

Appendix H: Post Self-Criticism Thoughts

Thinking about the biomechanical feedback on your sprinting performance (please circle on each):

(a) How often did you have self-critical thoughts?

Had none 1 2 3 4 5 6 7 8 9 10 A lot of the time

(b) How powerful were your self-critical thoughts?

Not at all 1 2 3 4 5 6 7 8 9 10 Very powerful

(c) How intrusive were your self-critical thoughts?

Not at all 1 2 3 4 5 6 7 8 9 10 Very intrusive

(d) How long did your self-critical thoughts last?

Fleetingly 1 2 3 4 5 6 7 8 9 10 Most of the time

(e) How distressed were you by your self-critical thoughts?

Not at all 1 2 3 4 5 6 7 8 9 10 Very distressed

(f) How angry/hostile were your self-critical thoughts?

Not at all 1 2 3 4 5 6 7 8 9 10 Very harassing

(g) How easy was it to distract yourself from your self-critical thoughts?

Not at all easy 1 2 3 4 5 6 7 8 9 10 Very easy

Appendix I: Performed Scenario Questionnaire

Reactions

1. Please rate the degree to which you reacted in each of the following ways to the biomechanical feedback on your sprinting performance. Your rating should be between 1 and 6 (1 = Not at all, 2 = Slightly, 3 = Somewhat, 4 = Moderately, 5 = Very, 6 = Extremely).

1. Remain calm and unflustered
2. Overreact
3. Experience strong emotions but not get carried away
4. Have no emotional reaction whatsoever
5. Take the feedback in stride
6. Set aside the feedback quickly in order to deal with my emotions
7. Replay the feedback in my mind constantly

2. Please rate the degree to which you reacted in each of the following ways to the biomechanical feedback on your sprinting performance. Your rating should be between 1 and 6 (1 = Not at all, 2 = Slightly, 3 = Somewhat, 4 = Moderately, 5 = Very, 6 = Extremely).

1. I tried to be kind to myself
2. I tried to make myself feel better
3. I was really hard on myself
4. I kept the feedback in perspective
5. I tried to do things to take my mind off of the feedback
6. I expressed my emotions to let off steam
7. I took steps to fix the problem or made plans to do so
8. I sought out the company of others
9. I gave myself time to come to terms with it

Appendix I: Performed Scenario Questionnaire

Thoughts

1. Please indicate the extent to which you thought each of the following thoughts about the biomechanical feedback on your sprinting performance. Your rating should be between 1 and 5 (1 = I did not think this thought at all, 2 = I thought this once, 3 = I thought this a few times, 4 = I thought this several times, 5 = I kept thinking this thought).

1. This is awful!
2. Everybody goofs up now and then
3. In the long run, this really doesn't matter
4. I am such a loser
5. This is embarrassing
6. This is sort of funny
7. I should have expected this would happen

2. Please indicate the extent to which you thought each of the following thoughts about the biomechanical feedback on your sprinting performance. Your rating should be between 1 and 6 (1 = Not at all, 2 = Slightly, 3 = Somewhat, 4 = Moderately, 5 = Very, 6 = Extremely).

1. I seem to have bigger problems than most people do
2. I'm a loser
3. This isn't any worse than what lots of other people go through
4. Why do these things always happen to me?
5. In comparison to other people, my life is really screwed up
6. Everyone has a bad day now and then

Appendix I: Performed Scenario Questionnaire

Emotions

Please indicate the extent to which you felt each of the following feelings about the biomechanical feedback on your sprinting performance. Your rating should be between 1 and 6 (1 = Not at all, 2 = Slightly, 3 = Somewhat, 4 = Moderately, 5 = Very, 6 = Extremely).

1. _____ Sad
2. _____ Dejected
3. _____ Down
4. _____ Depressed
5. _____ Nervous
6. _____ Fearful
7. _____ Worried
8. _____ Anxious
9. _____ Angry
10. ____ Irritated
11. ____ Mad
12. ____ Hostile
13. ____ Embarrassed
14. ____ Humiliated
15. ____ Guilty
16. ____ Ashamed

Appendix J: The Secondary Experiment

A secondary experiment was conducted after the completion of the original study. The main purpose of this secondary experiment was to explore the effects of familiarization on sprint performance. In the original study, to avoid participant's fatigue, the number of sprint sets were limited to four. In order to maximize the effects of biomechanical feedback, 100% frequency of feedback was used, and participants received biomechanical feedback at the end of each trial. Therefore, there was no control trial for the familiarization effects, and the first trial of sprint was considered as baseline for sprint performance. The results of the original study revealed that there was a significant improvement in sprint performance after the first presentation of biomechanical feedback at the end of first trial.

To see whether the familiarization could be responsible for this performance improvement, a secondary experiment with the same inclusion criteria and partial changes to the study design was performed on ten athletes that were not a part of the original study cohort. Table 1 and 2 show the participants' demographic and sociocultural information.

Table J.1

Age, Height, and Mass for the Participants

	Sex	*n*	*Range*	*Mean*	*SD*
Age (Years)	Female	1	19	-	-
	Male	9	18-28	22.11	3.06
Height (Centimeters)	Female	1	179.1	-	-
	Male	9	167.5-194	181.99	7.33
*Mass *(Kilograms)*	Female	1	61.23	-	-
	Male	9	61-86	82.25	13.29

* Mass data was self-reported

Table J.2

Participant Sociocultural Information

Ethnicity	*n (%)*	
	Female	Male
White	1 (100)	5 (55.5)
Latin American		1(11.1)
South east Asian		2(22.2)

The athletes performed four sets of 40-meter sprints with the same biomechanical data collection protocol but with no psychological questionnaires. They received the same biomechanical feedback after sprinting as the original study, but only started to receive feedback after the 2nd sprint rather than the first. The result of a repeated measure ANOVA analysis revealed that there was no significant effect on sprint performance between 1st and 2nd trials. It means that there was no familiarization effect on the sprint performance.

Additionally, the result showed that there was no significant improvement in the sprint performance after receiving and implementing biomechanical feedback. This finding does not reproduce the results of the original study which there was a significant improvement in sprint performance between 1st and 2nd sprint trials.

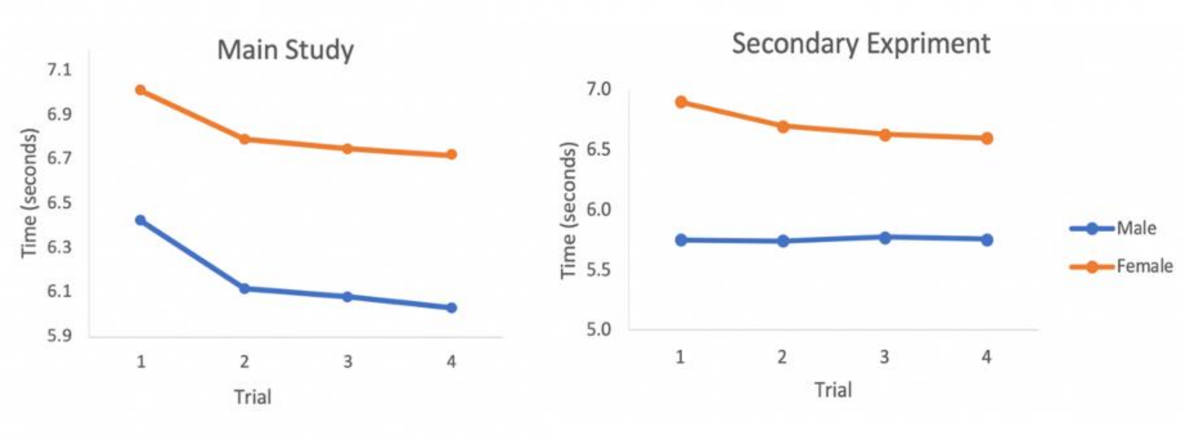

Figure J.1. The effect of receiving feedback on sprint performance. Left: Original study. There is a significant difference between 1st trial and the other trials. Right: Secondary study, with no feedback after 1st trial. As can be seen, there is no significant difference between trials.