How Spotting With Touch Affects Skill Performance and Self Confidence in Gymnasts

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Abstract

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Positive coaching techniques are gaining prominence in the sport of Gymnastics. Coaches are focusing on positive reinforcement, encouragement, and constructive feedback rather than relying solely on traditional, more authoritarian coaching methods. Furthermore, technology is being used to enhance coach-athlete relationships. Video analysis tools and performance tracking software allow for more detailed feedback and communication between coaches and gymnasts. Previous research has shown that sensory feedback, and physical cues and guidance impact both motor learning and motor skill performance. Spotting is a form of physical guidance (touch) that may be used by gymnastics coaches during both the learning phase of a skill and during performance, even after mastery. This research has examined whether and how spotting with touch influences the athlete's skill performance and confidence. The current study explored how spotting affects both skill performance and self-confidence of participants as they performed a basic skill (a backward jump onto a specified target) they have already mastered. We asked Intermediate-level gymnasts to perform a backward jump from height under two levels of landing difficulty, while being spotted with and without touch. Their confidence was measured in each condition using a brief survey. The timing, accuracy and precision of their landing was measured from video recordings of their performance. We evaluated the relationship between touch and skill performance to determine if it is affected by athlete self-confidence. It was hypothesized that physical guidance in the form of spot with touch would improve the accuracy and precision of the jump landing and that athletes would report higher levels of self-confidence in the touch versus no touch condition. We found no significant differences in skill performance and landing stability as assessed by rate of force development and peak force. We found that participants reported significantly higher levels of self-confidence when receiving spot with touch in the easy landing condition.

Keywords: skill performance, self-confidence, touch, spotting, physical guidance, gymnastics.

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Introduction

How Spotting With Touch Affects Skill Performance and Self Confidence in Gymnasts

Motor planning, control and sensory processing play an important part in motor skill learning and performance. People can practice by generating the information needed to perform skilled movements on their own, however, research shows that skill learning and performance benefits from coaching (O'Keeffe, Harrison, and Smyth, 2007). Coaches offer skill-related feedback in many forms, such as visual demonstrations or verbal corrections. This type of feedback is referred to as augmented feedback, any additional information provided to a learner about their performance during or after completing a task or skill. It is "augmented" because it supplements the natural sensory feedback that individuals receive from vision, touch and proprioceptive sensory information generated during their own movements (Wulf and Shea, 2002; Verwey et al., 2015).

In gymnastics, one form of augmented skill feedback is spotting, where the coach uses touch, applied in a routine manner, to orient or position the athlete so that they can replicate movements. Spotting is used when needed to reduce the risk of error and/or injury in performance, with the goal of achieving safe skill progression (Gymnastics Canada and Coaching Association of Canada, 2017). What are the needs of the athlete in situations that demand spotting and how does touch fulfill those needs? Unique to the sport of gymnastics is the relationship of trust between the coach and athlete (Daly et al., 2001). Coaches commonly provide their athletes with guidance or assistance through physical touch or cues. These physical cues may be a hand placed on the mid to upper back to ensure the athlete maintains upright posture or more supportive direct contact spotting where the coach uses both hands to hold and guide the athlete's hips towards a stable landing.

The current research investigates whether spotting with touch influences athletes' skill performance and confidence. We examine the relationship between touch and skill performance to determine if it is affected by athlete self-confidence. We look for differences in skill performance and participant self-confidence based on spotting condition (spot with touch and spot with no touch) and task difficulty, expecting that spotting will be more important as task difficulty increases. It is anticipated that physical guidance in the form of spot with touch will improve the accuracy and precision of the jump landing and that athletes will report higher levels of self-confidence in the touch versus no-touch spotting condition.

Background and Literature Review

In sports coaching, knowledge of results (KR) and knowledge of performance (KP) are two types of augmented feedback used to provide different types of information to athletes (Salmoni et al., 1984; Schmidt et al., 1989; Shea, and Wulf, 1999). Knowledge of Results (KR) is verbal feedback that provides the athlete with information about the outcome or result of the action, for example, the time needed to run 100 m. When participants are provided knowledge of the results of a movement task they demonstrate increased motivation to achieve this desired result and expend more effort and energy to perform the task correctly (Salmoni et al., 1984).

By contrast, KP provides information about the quality of a movement or skill, such as the form, technique, or execution of the movement, for example the athlete may be told to keep their core engaged during a jump in order to achieve better posture and landing stability. KP may be provided through verbal corrections, asking the athlete to attend to a particular aspect of the movement, as well as through physical guidance or assistance. Spotting is a form of physical guidance that may be used in the learning phase of a skill as well as during the performance of a skill which the athlete is already deemed competent to perform. In the case of a coach spotting an athlete, they are able to provide real-time feedback on the athlete's form and technique, which can help the athlete to adjust their movement and improve their immediate skill performance (Wulf and Shea, 2002).

Past research shows that feedback in the form of physical cues and guidance impacts the motor learning process and motor skill performance. Hegi, Heitz, and Kredel (2023) reviewed 26 studies that explored the potential of sensor-based augmented visual feedback training systems for complex movement tasks in sports. Their review focused primarily on visual feedback strategies and how they can enhance the feedback provided by coaches or therapists and improve sensorimotor learning in adults. Visual feedback specifically involves providing information about the performance of a motor skill through visual means, such as a diagram or video analysis. In their review, it was found that KR and KP were present in every study. Their review emphasizes the importance of including various feedback strategies to address different elements of a complex sport tasks and that psychological factors such as the athletes' mood or motivation has the potential to impact the efficacy of these feedback systems. Similarly, the current research examines the affect of athlete self-confidence on performance with guided feedback using spot with touch (SWT) and spot without touch (SWOT).

Guided feedback is a specific type of KP that involves providing explicit cues, hints, or instructions to guide the learner's performance. Guided feedback can be particularly useful during the learning phase of a new skill, as it helps the learner understand the correct technique or strategy. For example, in learning to play a musical instrument, a teacher might provide guided feedback by demonstrating the correct fingering for a challenging passage or giving verbal instructions on how to position the hands and use proper techniques. Guided feedback is often used in combination with other forms of augmented feedback, to facilitate skill acquisition and improvement.

Jeraj, Veit, Heinen, and Raab, (2015) undertook an exploratory study aimed to identify how gymnastics coaches consider different feedback factors that may influence the error-correction process. The study surveyed active gymnastics coaches, asking them to rank the importance and frequency of use of six feedback factors using a Likert-scaled questionnaire. The six feedback factors were: visual perspective, visual experience, motor experience, personal relationship between coach and athlete, methodological knowledge, and biomechanical knowledge. The study found that methodological knowledge was the prominent factor used in error-correction situations, and they recommend that future studies explore guided feedback methods to improve athletes' movements.

The Guidance Hypothesis

The guidance hypothesis describes how sensory information such as touch provided as augmented feedback, and other sensory inputs, help people to understand motor performance and learning (Salmoni, Schmidt and Walter, 1984; Schmidt et al., 1989). A central tenet of the guidance hypothesis states that it is important to consider when and how often guidance is used as this can have an impact on a person's ability to learn and perform a motor skill. It has been found that heavy reliance on augmented feedback will reduce performance errors and that the timing and frequency of feedback is directly related to motor learning success. The guidance hypothesis emphasizes the importance of considering the appropriate use of feedback techniques for optimal skill learning. For example, augmented feedback may be used to reduce errors in the learning phase, though it should not be relied upon as the sole type of feedback as this may hinder skill acquisition and retention. Further building on this, there are two ways in which coaches can direct the athlete's attentional focus during motor learning and performance – to an internal focus of attention (IFA) or an external focus of attention (EFA). IFA directs the athlete's attention to the actual movement and the sensations the athlete feels during the movement. By contrast, EFA directs attention to the affects of the movement in terms of outcome and the environment the movement is being performed. EFA can be related to augmented feedback in so far that it refers to the information a coach or instructor provides to the athlete about their movements. This can be in the form of KR or KP, including physical guidance through assistive spotting. Researchers have suggested that an external focus of attention (EFA) is more affective than an internal focus of attention (IFA) for learning and performance of motor skills (Wulf, McNevin, and Shea, 2001).

Research in sports further supports the superior affects of EFA over IFA. A meta-analysis on the acute affects of attentional focus strategies on muscular strength found a significant positive affect of external focus on muscular strength gains during resistance training (Grgic, Mikulic and Mikulic, 2021). It has also been found that athletes perform better when provided with instructions that promote an external focus of attention. In a study evaluating drop landing safety in female athletes, researchers found that the participants performed the landing with increased knee flexion and less leg stiffness when provided with instructions promoting EFA than when provided instructions promoting IFA (Almonroeder, Jayawickrema, Richardson, and Mercker, 2020).

When it comes to motor learning, for simple tasks it is important to increase the difficulty and demands of the practice conditions to continue to make learning gains. However, for difficult or more complex skills, such as those performed in sports – athletes may benefit from summary feedback (every few trials) and the learning process is enhanced when there are minimal interruptions (such as corrections) and task demands are reduced. Receiving additional support, through spotting or physical guidance has similar affects on skill learning as feedback. Too much physical guidance may render the performer dependent and hinders the learning process (Salmoni, Schmidt and Walter, 1984). The experience and skill level of the athlete as well as the complexity of the skill must be considered in order to optimize the benefits of feedback (Wulf and Shea, 1997; Wulf and Shea, 2002; Verwey et al., 2015).

As described by the guidance hypothesis, this theoretical framework suggests that providing external guidance too frequently during the learning process may hinder the development of motor skills. For example, providing instructions to someone learning a complex motor task, during the skill performance, may induce stress and be disadvantageous to their performance. Past research has found that giving instructions that specifically asked the performer to attend to their body movements during the task is detrimental, and does not enhance task performance (Wulf et al., 1998; Shea and Wulf, 1999). It's important for athletes learning complex motor skills to experience trial and error without physical assistance at first. This allows them to make errors, which is an important part of learning. Making errors allows the athlete to understand how and when to adjust their movements in situations where the skill is performed in sub-optimal conditions (Wulf, Shea and Whitacre 1998).

When learning sequences, movement order and movement control involve distinct cognitive processes (Verwey et al. (2015). Movement order is represented in short-term memory, meaning it is easier to learn and perform simple short movement sequences, while it requires more time and effort to refine and control the component movements. Wulf and Shea (2002) suggest that for complex movements such as those in sports, physical guidance may be beneficial as it reduces the information processing demands on the learner. However, perhaps the best results occur only after the participant has attempted the skill without assistance, being careful not to over-rely on physical guidance in the very beginning of the learning process. Heavy reliance on physical guidance could result in a failure to develop the adequate error-correction mechanisms and or lead to degraded skill retention and transfer in the absence of physical guidance (Salmoni, Schmidt and Walter, 1984.)

Wulf, Shea and Whitacre (1998) demonstrated that physical guidance can be beneficial in the learning phase as well as the performance of complex movements, such as those performed in sports. In their study involving a ski simulator, participants were provided physical guidance from ski poles which allowed them to have more freedom of movement, resulting in them experiencing the complex ski movements earlier than they would have in unguided practice conditions. It is more common for researchers to evaluate simple movement tasks such as the movement of a finger or limb. However, similar to the current study, Wulf, Sheas and Whitacre (1998) investigate a complex sports movement and how physical guidance impacts the performance of that movement. In their study the participants were asked to stand on a platform and transfer their weight and maintain balance as they would when skiing. This was done both with and without the use of a physical assistance device (ski poles) at varying time points. They found that the early use of physical guidance did not have a detrimental affect on the participant's ability to learn and perform the complex motor task, even in the absence of the physical guidance at a later time. Participants who were provided physical assistance in the form of ski poles demonstrated superior performance immediately following the assisted practice conditions, as well as superior balance and skill performance in the delayed tests, suggesting greater skill retention for the group who practiced with the physical assistance device than the group that practiced without physical assistance (Wulf, et al., 1998).

Touch as Guidance in Gymnastics

Physical touch is commonly used in gymnastics as a tool to provide feedback, guidance, and support to gymnasts. This can take many forms. A coach may use their hands to provide support or stability to a gymnast while they perform a skill, mainly if the gymnast is performing a skill that is particularly challenging or dangerous. In recent years, there has been increased awareness and concern about the issue of physical contact between coaches and gymnasts in gymnastics in light of global news coverage of high-profile cases of abuse and misconduct (Frederick, Pegoraro, and Smith, 2019). Policies related to physical contact between coaches and gymnasts have undergone significant changes in recent years. Many organizations have introduced stricter guidelines for when and how coaches can interact with their athletes (Gymnastics Ontario Safe Sport Code of Conduct and Ethics Policy, Section 8). Some have suggested coaches refrain from any form of spotting that involves touch, in particular at the beginner levels, while others have suggested spotting only be used to prevent catastrophic injury (Piper, Taylor, & Garratt, 2012).

Researchers have examined the role of touch in sports and have identified examples of positive touch, reasons for using touch and factors affecting how acceptable the touch is within the coach-athlete framework. Through analysis of athlete and coach interviews, Kerr et al. (2015) reveal that athletes view touch from a coach as a tool for enhancing the athlete's emotional well-being. Both athlete and coach state that a hug or pat on the back are forms of touch that could make the athlete feel more confident. Regarding when touch is acceptable, the lack of sports attire, such as wearing a leotard or swimsuit may be cause for certain types of touch to be seen as inappropriate (Kerr et al., 2015).

Past research has examined whether spotting an athlete during their performance can change how they perform a skill. Rykert, Larson, Harris, Adams, and DeBeliso (2017) found no difference in athlete's state anxiety or self-confidence when provided with only one spotter versus three spotters for one repetition of a back squat lift. However, their study tested male high school athletes performing an isometric exercise. In the current study we tested female participants performing a dynamic skill (a backward jump). Physical guidance, or spotting a gymnast can impact their posture, balance, and movement patterns. This can be both intentional and unintentional, and may be used to correct errors, guide the athlete through a skill, or provide stability and support. Although it is common for coach education to discourage physical contact between athletes and coaches, spotting remains to be an essential tool for teaching aesthetic sports such as gymnastics, diving and figure skating (Piper, Taylor, & Garratt, 2012; Gymnastics Canada and Coaching Association of Canada, 2017). One of the main goals of spotting is to enhance safety during practice and facilitate optimal conditions for learning new skills. Different types of spotting techniques may be used depending on the skill being performed. In some circumstances, the coach closely follows the gymnast through their routine, sometimes offering a bump to give them a little more acceleration, or acting as a safety net if a skill goes wrong (Fujihara, 2013). Spotting can be done hands-on, or with a spotting device such as a spotting belt which is a device that the athlete straps into like a harness and can manipulate their movements without the use of physical contact with the coach.

A common injury prevention policy in gymnastics includes having a coach present during skill performance, which includes spotting, as a key injury countermeasure (Daly, Bass, & Finch, 2001). The sport of gymnastics has been found to result in high levels of physical injury amongst both competitive and recreational participants (Daly et al., 2001). Kolt and Kirkby (1998) administered questionnaires to 162 competitive female gymnasts in Australia. They gathered data using psychological measures for life stress, self-esteem, competition anxiety and locus of control. Higher reported levels of life stress and injury rates were common among both elite and non-elite gymnast groups.

The intricacies of spotting require familiarity between the gymnast and the spotter. Unique to the sport of gymnastics is the relationship of trust between the coach and athlete. Because of this, spotting is sometimes debated as an affective technique for injury prevention (Daly et al., 2001; Pettrone & Ricciardelli, 1987; Priest, & Weise, 1981). Looking at the injury rate among club-level gymnasts, Pettrone and Ricciardelli, (1987) found that over 60% of injuries occurred when a spotter was present. Though in a similar study of college gymnasts with elbow injuries, it was reported that no spotter was present in 65% of cases (Priest, & Weise, 1981). Furthermore, psychological factors such as stress and self-confidence have been associated with gymnastics performance and injury rates (Mrđa et al., 2019; Kolt & Kirkby, 1998).

Gymnastics coach education courses often teach beginner coaches to focus less on providing physical guidance for skills, but rather on guiding the gymnast to build strength and confidence through the use of modern equipment placed within circuits or used in progressions and drills. As sport organizations attempt to move away from outdated coaching methods and practices, coaches and club owners have had to re-evaluate how they teach their sport. Many of the changes that have resulted have been positive and are leading to more positive coach-athlete relationships. However, some have suggested that the hands-off approach to coaching gymnastics could lead to a culture of fear and distrust (Piper, Taylor, & Garratt, 2012). To date, there is limited research examining the affects of spotting (touch) to improve learning and performance outcomes in gymnastics and other sports. The current study seeks to add insight and potentially contribute to filling this gap.

Self-Confidence and Sport Performance

Looking at the association between feedback, self-confidence, and skill performance, in general, athletes gain confidence as they master skills and accumulate successful performance experience. Having sports confidence means having self-confidence, which is the belief in one's ability to complete a physical skill or task required in sports. The connection between confidence and performance is complicated though as confidence does not always predict performance outcomes. Gagnon-Dolbec et al., (2019) investigated the association between self-confidence and sport performance in a group of lacrosse players. In their study participants were grouped based on level and whether they had high or low state sport confidence (as determined through a modified version of Vealeys State Sport Confidence Index (Vealey, 1986). Participants were asked to perform a lacrosse task, rate their self confidence in their performance, and receive feedback on their performance. One group received positive feedback, and the other received negative feedback, regardless of how they actually performed. It was found that the group that received negative performance feedback, provided lower sports confidence ratings on the subsequent trials, however, the lower confidence ratings did not impact the participants actual task performance. This suggests that although feedback affected how the players felt about themselves, it did not in reality have an affect on their task performance.

Confident athletes tend to be more skilled at using mental imagery, goal setting, and self-talk to enhance their performance (Gagnon-Dolbec, McKelvie, and Eastwood, 2017). Among athletes who are equally skilled, psychological factors, such as self-confidence, tend to play a more important role in determining performance outcome (Lochbaum, Sherburn, Sisneros, Cooper, Lane, & Terry, 2022). In a study involving a group of male college students with intermediate gymnastics experience (Mrđa et al., 2019), participants were asked to perform basic gymnastics elements on both the floor and the bars. A judging panel provided the performances with a graded score on a 1-5 Likert-type scale. Participant self-confidence was defined through measures obtained on the RSES (Rosenberg self-esteem scale) and the SC-6 (Bracken's multidimensional self-concept model). The researchers found significant positive correlation between the score for the performance of gymnastics skills on the floor and participant self-confidence. In this study the psychological measure of self-confidence significantly positively correlated with higher gymnastics performance scores.

Although it is clear that spotting has the potential to provide information – KP – that could be used by gymnasts to improve learning and performance, there has been very little research directly examining its affect on skill performance or on performance confidence. This thesis addressed this void by examining how spotting influenced performance of a backward jump from height at two levels of difficulty. Difficulty was manipulated by changing the landing requirements. The importance of the landing and how landing stability can be measured will be elaborated on below.

Coach education programs place a strong emphasis on safety, risk management, and injury prevention, with a focus on understanding how to create a safe training environment for gymnasts. Research related to abrupt versus gradual landings in sports, such as gymnastics, has focused on understanding the biomechanical, physiological, and performance implications of different landing techniques. Several studies have investigated the affects of abrupt versus gradual landings on factors such as force attenuation, injury risk, performance outcomes, and skill development in gymnastics and other sports involving similar landing demands (Hallgrimson, 2020; Seegmiller and McCaw, 2003).

In general, gymnasts are trained to execute landings with control, stability, and proper technique to minimize the risk of injury and optimize performance. Gradual landing refers to a progressive increase in force or load during a performance test. Gymnasts are trained to land with proper technique, which may involve a gradual absorption of force through controlled bending of the knees and ankles, and maintaining stability throughout the landing (Kratzenstein, Grimm, & Hansen, 2020). This can help distribute the impact forces evenly and reduce the risk of injury. Abrupt landings, where the force is absorbed suddenly and without proper control, can increase the risk of injury, especially on hard or unforgiving surfaces. Gradual landings, on the other hand, allow the gymnast to gradually adapt to the impact forces, reducing the risk of acute overloading or tissue damage. Abrupt landings more commonly occur where the skill being performed requires explosive or reactive capabilities, such as tumbling or vaulting. In the current study, the participants were asked to perform a basic backward straight jump. Intermediate level gymnasts are taught to land this type of jump with control, whether it is performed on the floor or on the beam.

The rate of force development (RFD) during landing refers to how quickly an individual is able to generate force upon initial contact with the ground (Miller, Fry, Ciccone, & Poggio, 2023). It is a measure of how rapidly force is produced during a specific time interval, typically from the time of initial contact to the peak force. RFD is an important parameter in assessing landing stability as it reflects the ability of an individual to rapidly generate force to absorb and control the impact forces associated with landing. A higher RFD indicates a faster rate of force production, which can be indicative of better landing stability (Seegmiller and McCaw, 2003; Miller, Fry, Ciccone, & Poggio, 2023). This means that the individual is able to quickly generate force upon landing, which can help absorb the impact and control the landing forces more affectively, resulting in a more stable landing. On the other hand, a lower RFD may indicate slower force production and potentially reduced ability to absorb and control landing forces, which could result in less landing stability (Dehcheshmeh, Gandomi, and Maffulli, 2021; Searle, 2023). Gymnasts experience higher ground reaction force when landing than other types of athletes, (Seegmiller and McCaw, 2003), possibly due to their training to “stick the landing”.

Brown et al. (1996) investigated ground reaction forces in the dismount from the balance beam under two styles (stick and roll-out of the landing) and found that attenuation of relatively high impact forces through modification of landing may be used to reduce the exposure of gymnasts to injury. Another study compared experimental protocols for measuring forces using force platforms during landings on competition mats and found that reducing the size of the landing mats and keeping the area surrounding the force platform clear was the preferred method for collecting landing force data (Buxton, Hiley, & Yeadon, 2022). In the current study we assess the participants landing ability on a narrow target (difficult landing simulating the balance beam) and within a rectangular box target (easy landing simulating the floor exercise).

In the current study, participants skill performance is assessed using a force plate and using kinematics gleaned from video recordings to measure landing accuracy and consistency. Traditional force plates are typically mounted to the ground, making them difficult to transport and use outside of a laboratory setting. Portable force plates have been developed to address this issue. The reliability of portable force plates has been established through validation studies where the force plate is used on its own (Walsh, Ford, Bangen, Myer & Hewitt, 2008; Kowasaki, Ogawa, & Takahashi, 2021) or in combination with other tools, such as motion capture, to evaluate human balance and gait features (Savadkoohi, Oladunni, & Thompson, 2021). The current approach examined backward jump performance under two spotting condition (touch present or absent) and two task difficulties (easy landing, similar to floor exercise and difficult landing, similar to balance beam), and looked at how self-confidence affects gymnastic skill performance.

Method

Participants

In total we recruited 16 participants to volunteer for this study. All participants reported to be healthy, with no injuries or limitations that would prevent them from safely completing the study tasks. All the participants were female who self-reported intermediate level gymnastics experience. The participants ranged in age from 13 years to 22 years in age (M=16.5 +/-2.8 years). Participants reported to be involved in gymnastics or a gymnastics-related physical activity such as conditioning exercise, stretching, or parkour, for an average of 7.3 hours per week (+/- 4.8 hrs). The years of gymnastics experience for this group of participants ranged from 3 years to 16.5 years (M=8.5, +/-3.63). This study received approval through the Trent University Research Ethics Board (file# 27918). All participants consented or assented to participate in the study. For the five participants who were under the age of 16, consent was provided by a parent.

Participants were required to have at least 3 years of prior gymnastics experience and competency in the necessary skills for CANGYM levels 4 – 7. The skill the participants were required to perform was a standing backward jump from a 51cm height surface, a skill needed to pass CANGYM level 3. These requirements ensured the participants were capable of performing that skill adequately. People who are more advanced than CANGYM level 7 were excluded to ensure we could assess a population that was refining their jump and landing skills, allowing for us to better assess the influence of touch on that refinement process. The participants in this study met the inclusion and exclusion criteria through self-report. Participants were scheduled in 60 minute time slots, however most participants completed the study tasks within 30 minutes.

Table 1

Participant Demographics

Age	Years of gymnastics experience	CANGYM level	Number of hours spent training per week
17	11	7	3
16	6	5	5
16	11	7	9
20	10	7	2
19	7	7	2
19	10	7	10
15	5	4	3
13	9	7	4
13	4	5	4
19	16.5	6	6
17	7	7	8
16	7	7	20
13	11	7	9
13	3	7	9
22	13	7	9
17	7	7	14

Note. This table provides demographic information self-reported by study participants

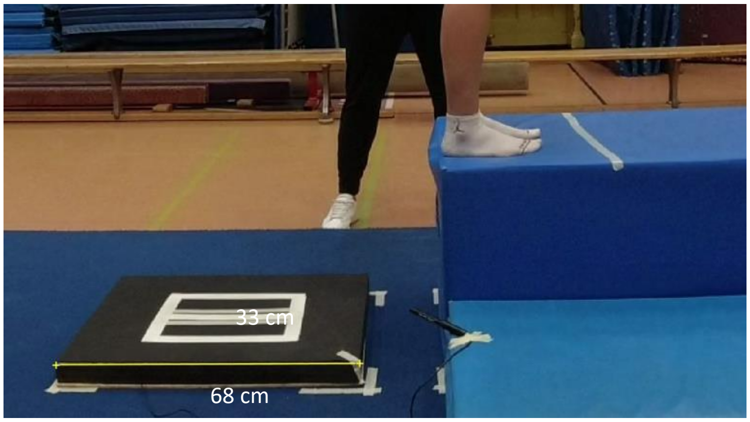
Apparatus

The study trials were conducted in the gymnasium at a community centre in Toronto, Ontario. During the study trials the doors to the gymnasium remained closed to ensure privacy and only the participant, the coach and primary investigator and a research assistant were present.

The gymnasium was set-up with one floor mat, a standard spotting block (Speith Gymnastics, Altbach, Germany; 152 cm in length x 61 cm in width x 51 cm in height) commonly used to perform jumps and a matted landing surface (Speith non-flex carpet bonded foam roll; 183 cm in width x 1280 cm in length x 3.5 cm in thickness) in which the force plate (Vernier FP-BTA, Vernier Science, Beaverton, Oregon, USA; 33.0 cm x 33.0 cm x 4.0 cm) was embedded (see Figure 1) . All gym equipment was standard for use in gymnastics and in good condition.

Figure 1

Gymnasium equipment set-up.



Note. Force platform measures 68cm x 58cm x 4cm. Target landing area measures 33 cm x 33 cm, containing a center landing “line” measuring 10 cm x 33 cm.

The force plate data were collected using Vernier Graphical Analysis Pro software. The force plate was configured to collect 200 samples per second. Collecting 200 samples per second allows for more precise and accurate measurements of force and movement and was done based on the standard in neuroscience research (Walsh, Church, Hoffmeister, Smith, and Haworth, 2021; Miller, Fry, Ciccone, and Poggio, 2023). The Graphical Analysis Pro software was running on a personal computer (Samsung 780Z5E, Samsung Corp., Suwon, South Korea) and the force plate was embedded inside of a custom 68 cm x 58 cm wooden frame padded on the top with black, textured vinyl matting. The matting was flush with the frame and force plate. This was thin enough to not interfere with landing force measurements but also provided stability and comfort for the participant in the event that they did not land directly on the force plate.

Video recording of each jump trial was done using a DJI Osmo Action high-definition video camera (DJI, Shenzhen, China) mounted to a tripod. All sensors were set to begin recording with a sound cue using a Vernier microphone affixed to a mounting block (see Figure 1). Videos were initially stored on an SD card, then uploaded and stored on a secure file sharing platform accessed through the Trent University server (OneDrive, Microsoft Corp, Redmond, WA, USA).

Anthropometric measures of the length of the arm, forearm, thigh and leg were taken from each participant prior to beginning the jump trials using ISB standards for whole body orientation (Wu and Cavanagh, 1995). This provided scale and informed us about distances which was necessary for accurate video analysis. Anthropometric measures were taken from each participant using a standard measuring tape (cm). We measured participants arm length from the acromion to the lateral epicondyle. Forearm measurements were taken from the lateral epicondyle to the ulnar head. Thigh measurements were taken from the top of the iliac crest to the knee bend. Leg measurements were taken from the knee bend to the ankle bone.

A self-report questionnaire (see Appendix B) was used to learn which CANGYM level best described the participants gymnastics abilities, how long they had been practicing gymnastics and how often they practiced gymnastics or gymnastic-related activities or conditioning in a typical week. Each participant was provided with an overview of the CANGYM level requirements so that they could provide an informed estimation of which level they felt best described their gymnastics abilities.

Design

Using a 2-spotting (SWT and SWOT) by 2-landing difficulty (easy, difficult) full factorial within-participants design, participants were exposed to all four experimental conditions in a counterbalanced order. In each condition participants performed a standing backward straight jump from a spotting block measuring 51cm in height. The participants were instructed to land as they would on the floor (easy) or on the beam (difficult) on specific markings overlaying a force plate, experiencing different spotting conditions. The landing difficulty was varied by asking them to land as they would on the floor (easy landing) or as they would on a beam (difficult landing). For the easy landing participants were asked to land within the perimeter of a rectangle that was drawn on the matted surface of the force plate (33cm x 33cm), mimicking a typical floor landing. For the difficult landing participants were asked to land on a 4-inch wide rectangular outline, representing the width of a balance beam within the rectangular “floor” surface. These targets were clearly marked on the landing surface with white athletic tape.

We also varied whether the spot provided by the coach included a physical touch (SWT), with hands placed on the participant's low back and leg, or if the coach would spot by simply standing in close proximity to the side of the participant, ready to reach in if the participant were to experience difficulty (SWOT). The participant was asked to perform 5 jump trials for each of the 4 experimental conditions. The participants were exposed to each condition in counterbalanced order. This was done to minimize the potential order affects, carry-over or learning affects.

Self-confidence

The participants were asked to provide verbal Self-confidence (SC) scores at six time points throughout the study visit (See Table 2 for the specific questions asked). This was done by asking participants to state their score on a scale from 1 to 10, with 1 being not confident at all and 10 being absolutely confident. Participants were instructed only to state one number and this number was recorded as their score.

Table 2

Questions used to assess participant self-confidence

Condition	Question used to assess participant self-confidence
PRE – Experimental	Based on the instructions provided, how confident are you on a scale of 1 – 10 in your ability to perform these tasks – where 1 is not at all confident and 10 is 100% confidence?
Four Experimental Conditions	Based on the instructions provided, how confident are you on a scale of 1 – 10 in your ability to perform this task – where 1 is not at all confident and 10 is 100% confidence?
POST-Experimental	Based on your experience overall, how confident are you on a scale of 1 – 10 in your performance – where 1 is not at all confident and 10 is 100% confidence?

Self-confidence was measured at 6 different time points. First, after receiving instructions but before beginning the jump trials the participant was asked to provide a score for their overall self-confidence in their ability to complete the study tasks, we called this the pre-experimental condition (PRE). The participant was asked to provide additional self-confidence scores prior to beginning their jumps in each of the four experimental task conditions. After completing all task conditions the participant was asked to provide a final self-confidence score based on how well they felt they performed overall, we called this the post-experimental condition (POST).

Kinematic data was captured by video and analysed using Tracker, version 6.1.2 (Brown, Christian, & Hanson, 2023; https://physlets.org/tracker), an open access video analysis and modelling tool. The force-plate was used to measure forces applied to the floor during landing as a proxy for landing stability. The force plate was configured to collect 200 samples per second for a maximum of five seconds once the sensors were triggered by the experimenter saying “go”. Furthermore, the data collection software was programmed to record 200 points before the triggering event. A diagram of the setup can be found in Appendix C.

Peak Force

Due to the vinyl matting and casing surrounding the force plate, upon zero-ing the device, a force of 1.22-3 Newton’s was recorded. Therefore, we only considered a force greater than 3 N to be the initial onset of contact force. Peak force was defined as the highest force value recorded for each trial. A representative graph of force (N) over time (s) can be found in Appendix A.

Rate of force development (RFD)

Rate of force development was used as a measure of landing stability, where a higher rate of force development reflects a more stable landing. Rate of force development is defined as the change in force between initial force and peak force divided by the change in time between peak force and initial force. This calculation provided an estimate of the speed at which force was developed during this specific time interval expressed in units of force per unit of time (N/s).

Accuracy

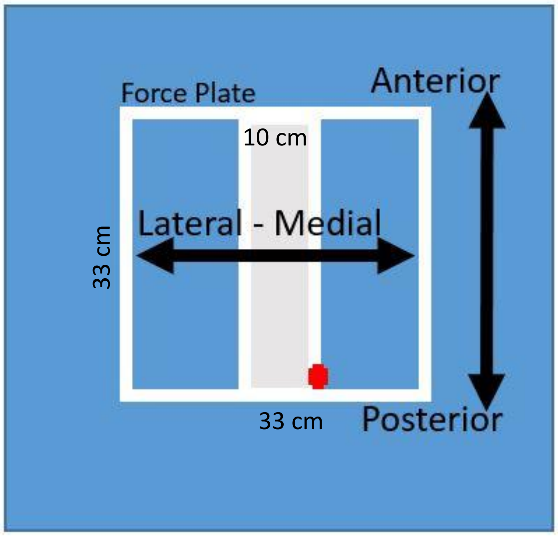
We used Tracker Video Analysis software to assess the accuracy of the participants landing across each condition. Video files were uploaded individually for each attempt. To determine the frame of interest we selected based on the moment that the participant’s right innermost toe makes first contact with the force plate. The origin of the axis used to measure accuracy and precision is shown on figure 3.

Anterior-Posterior landing accuracy was assessed to determine if participants toe landed in front of or behind the target. Medial-Lateral landing accuracy was assessed to determine if participants landed in to the left or right of the target.

The landing accuracy values were extracted from the Tracker software and put into a Microsoft Excel spreadsheet. Each participant was recorded for 5 jump trials in each of the 4 experimental conditions, for a total of 20 jumps. In each condition the positon of the participants’ innermost toe on their right foot was recorded in meters (m) from the line target. A value indicating the anterior-posterior (A-P) and the medial-lateral (M-L) position of the innermost toe were recorded as landing accuracy measures.

Figure 2

Overhead rendering of matted platform with embedded force plate.



Note. Red indicator marks the origin of the axis used to compare measurements.

Precision

Precision is a measure of how consistently participants landed on the target over the 5 trials within each condition and is a hallmark of skilled performance. The standard deviation of the values for A-P and M-L landings were used to determine landing precision.

Procedure

Each study session followed a uniform procedure. Participants were welcomed into the gymnasium by the primary investigator/coach and provided time to review the informed consent form, ask questions and fill out the participant questionnaire.

Participants were then instructed to proceed onto the floor mat where they were given 5 minutes to warm up. Each participant was guided through the same general warm up which included 1 set of 3 forward jumps and 1 set of 3 backward jumps on the matted floor area. Prior to beginning the jump trials, participants were instructed to perform 1 practice jump from the block in each of the experimental conditions, for a total of 4 practice jumps from the block onto the matted force plate landing surface. This was done to ensure the participants had a clear understanding of the tasks.

Participants were provided with instructions on how to perform the backward jump with proper form. They were instructed to jump vertically up and back into the air with an extended body, moving backwards, to land on the target. The backward jump should begin and end with standard gymnastics presentation, with arms raised up above the head. Participants were instructed to land as they typically would on either a balance beam (difficult landing on the line with feet in heel-to-toe position) or the floor exercise (easy landing inside the box with feet positioned side-by-side).

Measures of self-confidence were collected by asking participants to verbally indicate how confident they were in their ability to perform the jump on a 1 – 10 scale (1 meaning not confident at all, expecting to have or have had form and landing errors at every attempt, and 10 meaning completely confident that they can perform or have performed the skill without errors 100% of the time). Participants were asked to provide a self-confidence rating after their warm-up (PRE), prior to beginning the jump trials in each of the 4 experimental conditions (SC1, SC2, SC3, SC4), and after they completed the jumps in all conditions (POST). When all jumps were complete, they were thanked for their time.

Statistical Analysis

All data was assessed for outliers and normality prior to submitting to statistical analyses. Any cases where the resultant value was found to be greater than +/- 3 standard deviations from the mean, would be considered an outlier and removed without replacement. We used the Shapiro-Wilks test to assess the normality of our data. Shapiro-Wilks test is recommended for samples of less than 50 (Field, 2018).

There were no outliers, as assessed by examination of studentized residuals for values greater than ±3. Peak force and RFD were both found to be normally distributed as assessed by the Shapiro-Wilks test of normality on the studentized residuals ($p > .05$).

The participant's 5 jump attempts were recorded for anterior-posterior (A-P) and medial-lateral (M-L) landing accuracy. A-P landing accuracy was found to be normally distributed in the difficult landing-spot with touch condition, difficult landing-spot without touch condition and the easy landing-spot with touch condition ($p > .05$), but not in the easy landing spot without touch condition ($p = .008$) as assessed by Shapiro-Wilk's test of normality on the studentized residuals. In condition 4 (easy landing-spot without touch) the data was found to be right skewed. One outlier value was removed.

For M-L landing accuracy there were no outliers, as assessed by examination of studentized residuals for values greater than ±3. Lateral-medial landing accuracy was found to be normally distributed as assessed by the Shapiro-Wilks test of normality on the studentized residuals ($p > .05$).

Statistical analyses were conducted using IBM SPSS Statistics v 29.0 software. Each dependent measures was each submitted to a 2-task difficulty (easy-box landing, difficult-line landing) x 2-touch spotting (with touch and without touch) repeated measures analysis of variance. Interactions were decomposed by examining simple main affects. Alpha was set at 0.05. We chose to report partial eta squared to ensure we were only considering the affects of the dependent variable in question and not including any affects from other independent variables or interactions.

Results

In this study the participants were asked to perform either a difficult landing, simulating a landing on a 4-inch wide balance beam, or an easy landing, simulating a landing on the floor exercise, under two spotting conditions: spotting with or without touch. Skill performance was measured by calculating peak force and the rate of force development (RFD). RFD is an important parameter in assessing landing stability as it reflects the ability of an individual to rapidly generate force to absorb and control the impact forces associated with landing, such that higher values reflect greater landing stability (Brown et al., 1996; Miller et al., 2023). Skill performance was also assessed for anterior-posterior (A-P) and medial-lateral (M-L) landing accuracy, by determining how much the participants deviated from their target landing (box or line) throughout the 5 jump trials in each condition, and for A-P and M-L precision, by examining landing variance (the standard deviation of accuracy). At the start of the study visit, at the end of each condition, and at completion of all trials, the participants rated their confidence on a scale from 1-10.

Measures of Jump Performance

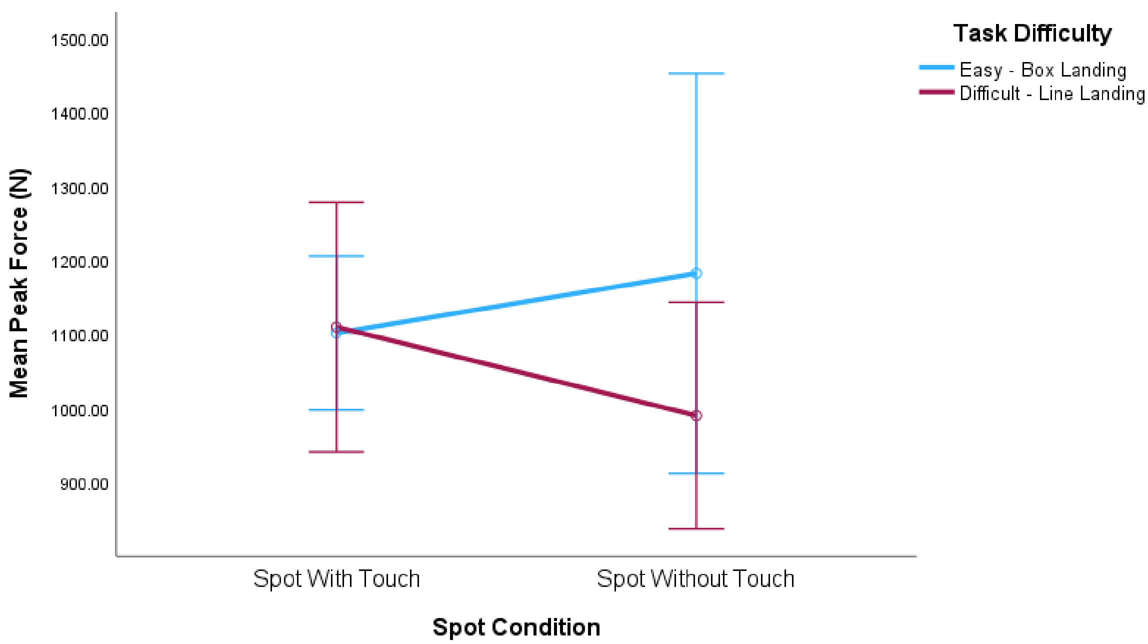
Peak force (Newtons (N)) and rate of force development (N/s), accuracy and precision were submitted to separate 2-Task Difficulty (box-landing, line-landing) x 2-Touch Spotting (present, absent) repeated measures analysis of variance.

Peak Force

There was no significant main affect for spot condition, $F(1, 15) = .81$, $p = .780$, pη2= .005, no significant main affect for task difficulty, $F(1, 15) = 1.93$, $p = .185$, pη2= .114, and no significant interaction, $F(1, 15) = 2.14$, $p = .164$, pη2= .125. These results are shown in Figure 3.

Figure 3

Interaction Plot for Task Difficulty and Spot Condition on Peak Force



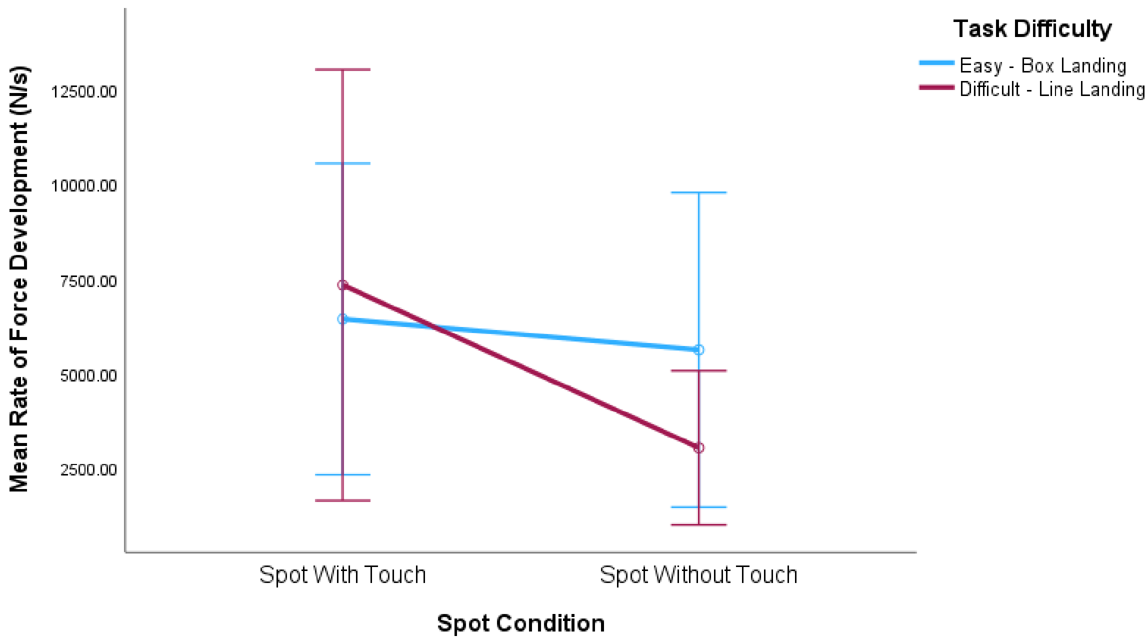
Note. These differences were not statistically significant. Error bars show 95% confidence intervals.

Rate of Force Development

Rate of force development (RFD, N/s; see Figure 4) was submitted to a 2-task difficulty (easy – box landing, difficult – line landing) x 2-touch spotting (present, absent) repeated measures analysis of variance. There was no significant main affect for task difficulty, *F*(1, 15) = .371, *p* =.552, pη2= .024, no significant main affect for spot condition, *F*(1, 15) = 1.88, *p* = .190, pη2= .111, and no significant interaction, *F*(1, 15) = .515, *p* =.484, pη2= .033. These results are shown in Figure 4.

Figure 4

Interaction Plot for Task Difficulty and Spot Condition on Rate of Force Development



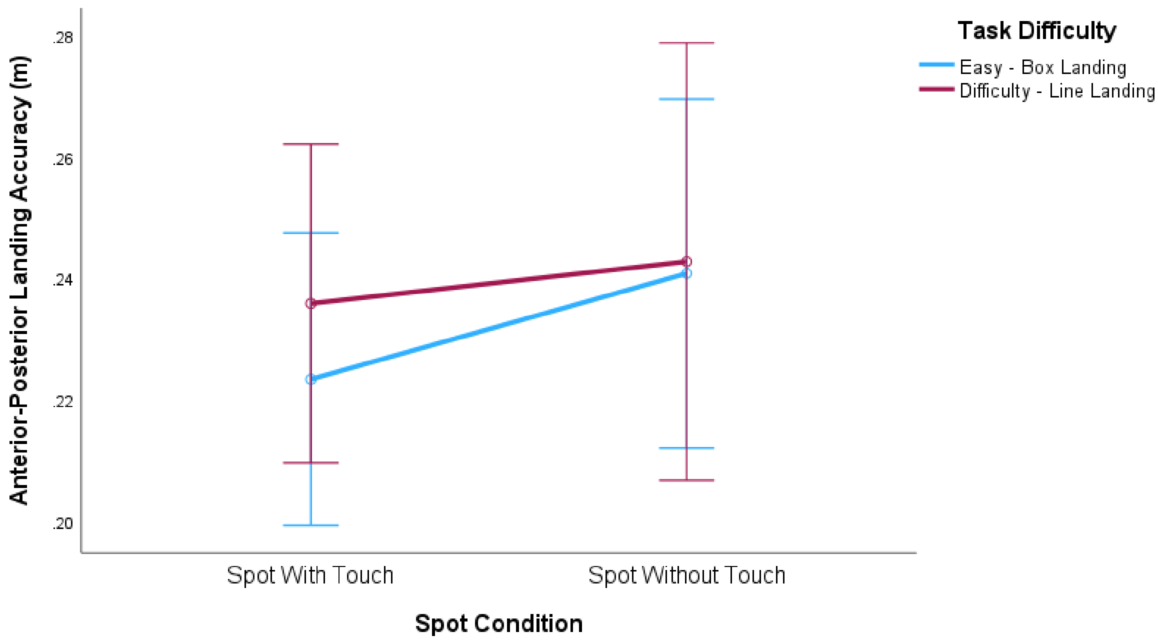
Note. These differences were not statistically significant. Error bars show 95% confidence intervals.

Anterior –Posterior Landing Accuracy

The main affect of task difficulty did not produce a statistically significant difference in anterior-posterior landing accuracy, *F*(1,15) = .512 *p* = .485, , pη2= .033. The main affect of spot condition did not produce a statistically significant difference in A-P landing accuracy, *F*(1, 15) = 2.486, *p* = .136, , pη2= .142. There was no statistically significant two-way interaction between spot condition and task difficulty, $F(1, 15) = .828$, $p = .377$, pη2= .052. These results are shown in Figure 5.

Figure 5

Interaction Plot for Task Difficulty and Spot Condition on Anterior-Posterior Landing Accuracy



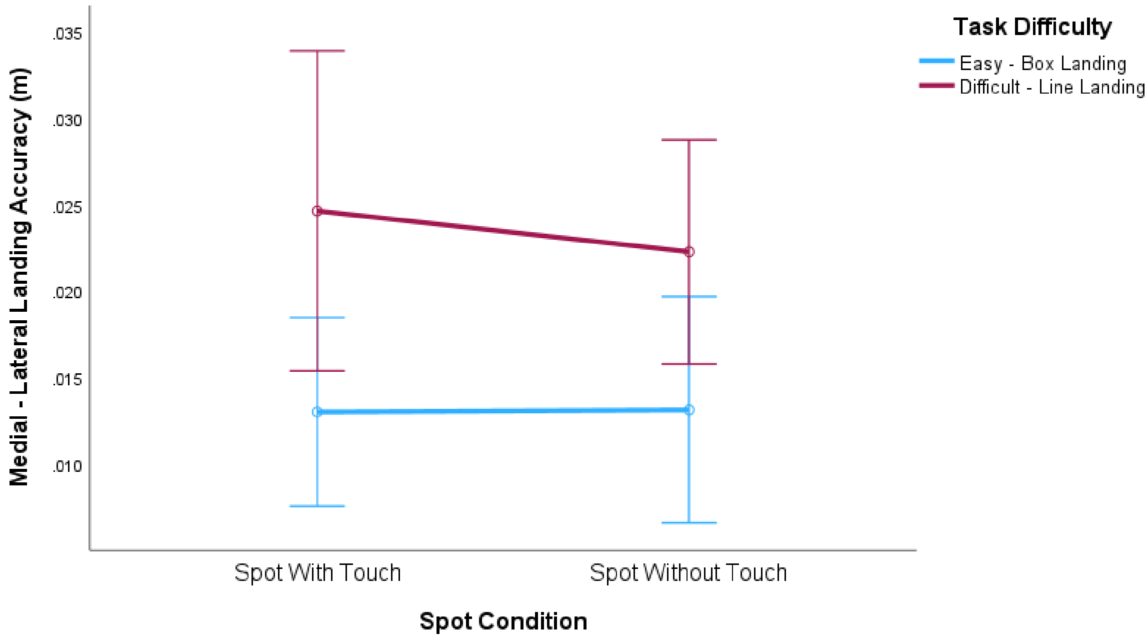
Note. No significant differences were found in anterior-posterior landing accuracy. Error bars show 95% confidence intervals.

Medial-Lateral Landing Accuracy

There was no statistically significant two-way interaction between spot condition and task difficulty, $F(1, 14) = .30$, $p = .593$, pη2= .021. The main affect of spot condition did not produce a statistically significant difference in M-L landing accuracy, $F(1,14) = .206$, $p = .657$, pη2= .014. The main affect of task difficulty showed that there was a statistically significant difference in M-L landing accuracy $F(1,14) = 11.481$, $p = .004$, pη2= .45. These results are shown in Figure 6.

Figure 6

Interaction Plot for Task Difficulty and Spot Condition on Medial – Lateral Landing Accuracy



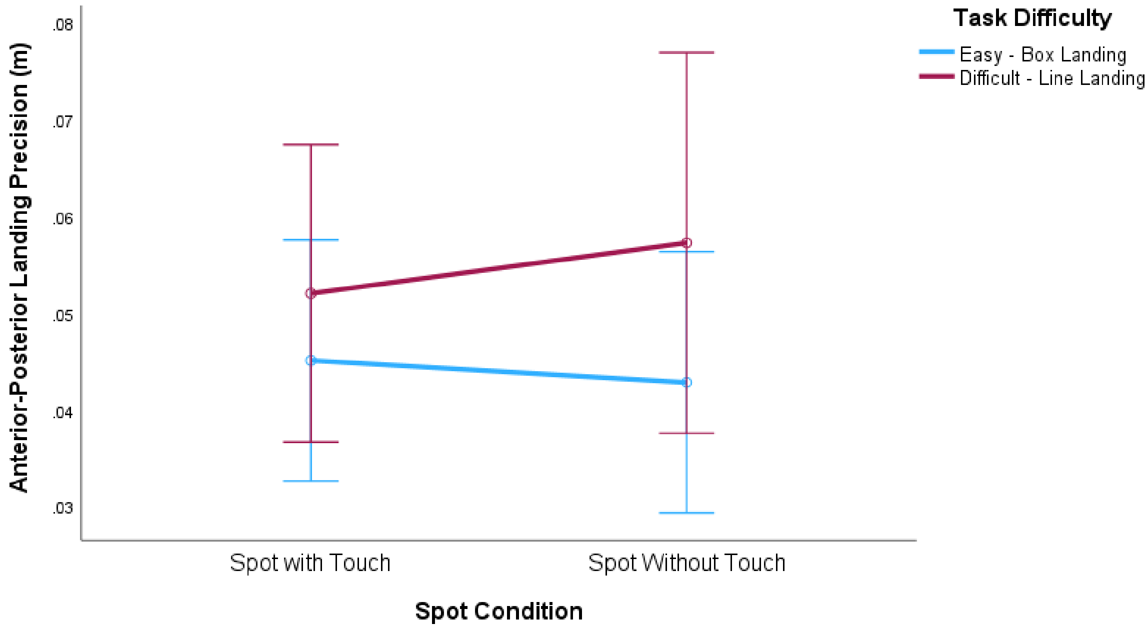
Note. These differences were not statistically significant. Error bars show 95% confidence intervals.

Anterior-Posterior Landing Precision

There was no statistically significant two-way interaction between spot condition and task difficulty, $F(1, 15) = .585$, $p = .456$, pη2= .038. The main affect of spot condition did not produce a statistically significant difference in anterior-posterior landing precision, $F(1, 15) = .052$, $p = .822$, , pη2= .003. The main affect of task difficulty did not produce a statistically significant difference in anterior-posterior landing precision, $F(1,15) = 2.169$ $p = .162$, , pη2= .126. These results are shown in Figure 7.

Figure 7

Interaction Plot for Task Difficulty and Spot Condition on Anterior-Posterior Landing Precision



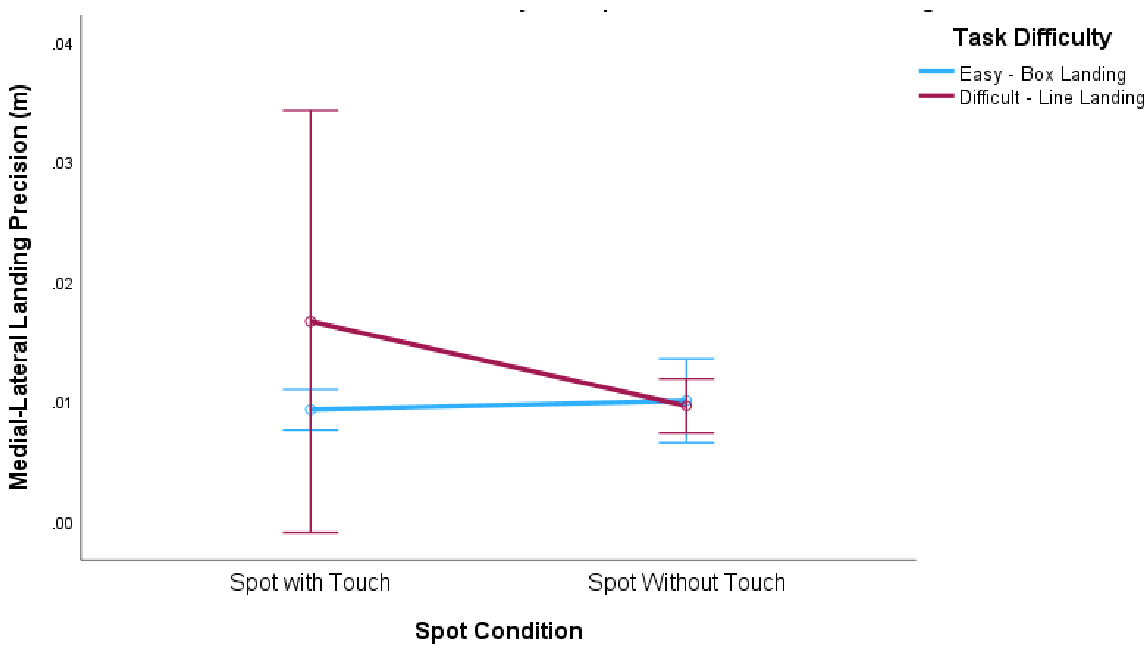
Note. No significant differences were found in anterior posterior landing precision. Error bars show 95% confidence intervals.

Medial-Lateral Landing Precision

The main affect of spot condition did not produce a statistically significant difference in M-L landing precision, $F(1,15) = .567$, $p = .463$, pη2= .036. The main affect of task difficulty did not produce a statistically significant difference in medial-lateral landing precision, $F(1,15) =$ .647 $p = .434$, , pη2= .041. There was no statistically significant two-way interaction between spot condition and task difficulty, $F(1, 15) = .945$, $p = .346$, pη2= .049. These results are shown in Figure 8.

Figure 8

Interaction Plot for Task Difficulty and Spot Condition on M-L Landing Precision



Note. No significant differences were found in medial-lateral landing precision. Error bars show 95% confidence intervals.

Self-Confidence

These measures were collected at 6 different time points: Pre-experimental, before the participants started the trials (PRE), prior to beginning 5 trials in each condition (SC1, SC2, SC3, SC4) and post-experimental, after the participants completed all trials (POST).

Table 3

Measures of participant self-confidence

	N	Mean	Std. Deviation
Pre-experimental self-confidence	16	8.06	1.44
Post-experimental self-confidence	16	8.37	1.31
Self-confidence prior to beginning condition 1 (Difficult landing, spot with touch)	16	8.00	1.75
Self-confidence prior to beginning condition 2 (Difficult landing, spot without touch)	16	7.75	1.98
Self-confidence prior to beginning condition 3 (Easy landing, spot with touch)	16	9.06	.93
Self-confidence prior to beginning condition 4 (Easy landing, spot without touch)	16	8.19	1.94

Self Confidence as a Function of Spotting and Difficulty

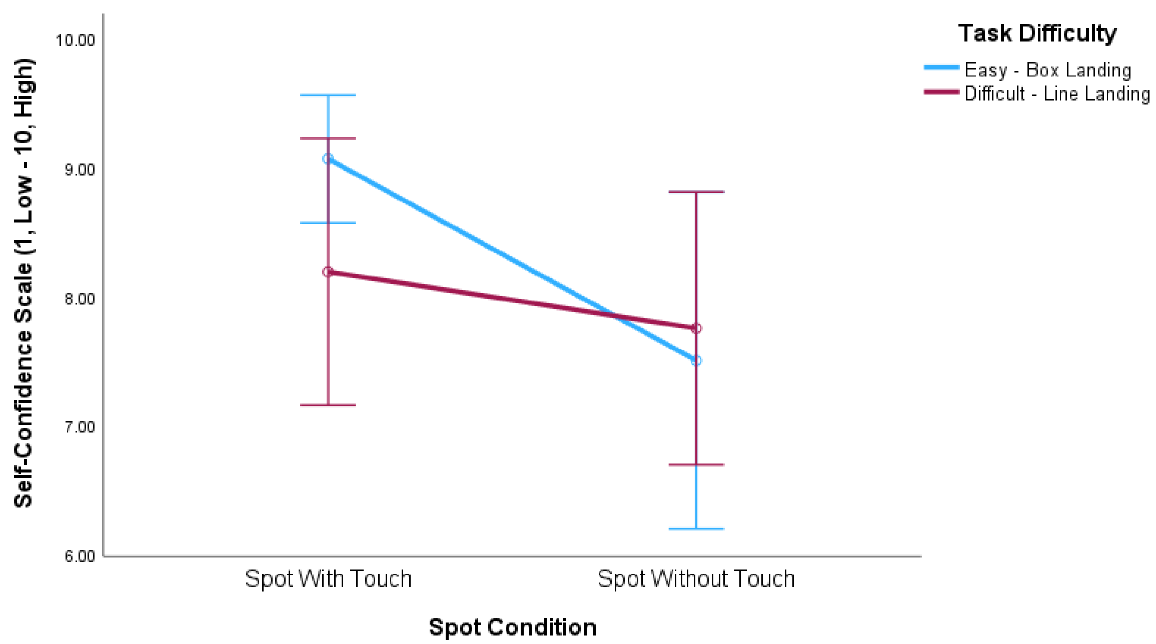
Analysis of studentized residuals revealed that the self-confidence scores were heavily left skewed, as assessed by the Shapiro-Wilk test of normality. Therefore, the data was transformed using a log reflect transformation. The transformed data were submitted to a 2-Task Difficulty (circle-landing, line-landing) x 2-Touch Spotting (present, absent) x 4 (time point) repeated measures analysis of variance.

The type of spotting the participant received was found to have a significant main affect on the participants self-confidence $F(1, 15) = 13.66$, $p = .002$, $p\eta 2 = .477$. We observed that the participants reported significantly lower levels of self-confidence when performing with spot without touch (M=7.88, S=.448, 95%CI= 6.92 to 8.83), than when performing with spot with touch (M=8.63, S=.28, 95%CI= 8.03 to 9.22).

There was no significant main affect of task difficulty, $F(1,15) = 3.235$, $p = .092$, pη2=.177. Self-confidence was not different in the difficult landing condition than in the easy landing condition. There was no statistically significant two-way interaction between spot condition and landing difficulty, on self-confidence in performance ability $F(1, 15) = 1.846$, $p = .194$ pη2 = 0.11. These results are shown in Figure 9.

Figure 9

Interaction Plot for Task Difficulty and Spot Condition on Self-Confidence



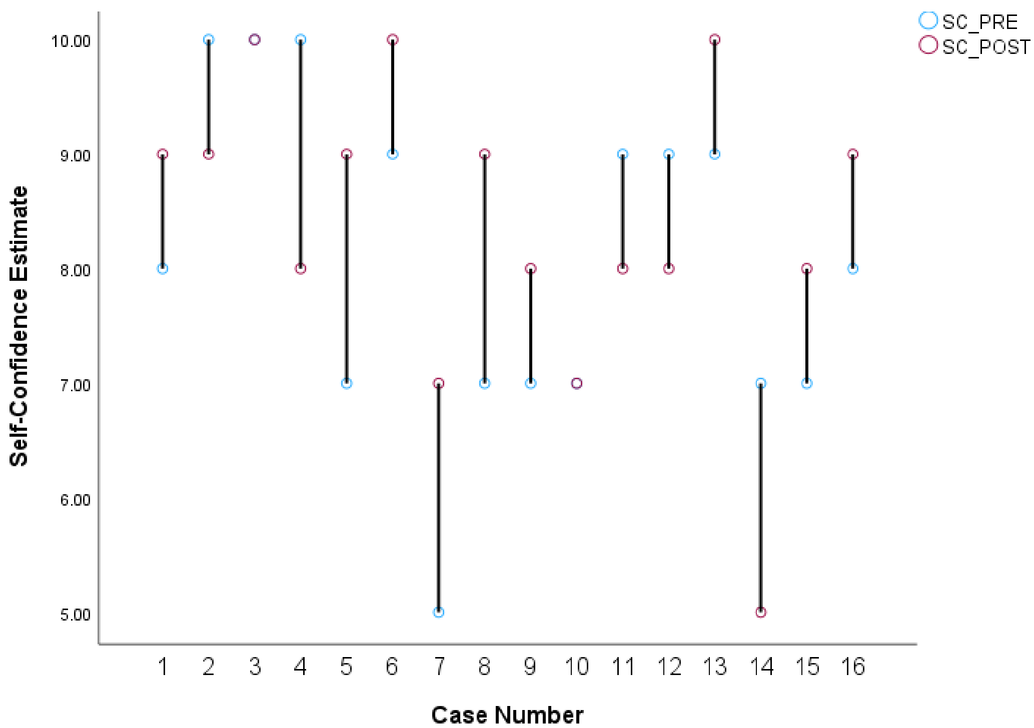
Note. Participants reported higher levels of self-confidence when spotted with touch than when spotted without touch, between the trial conditions. Error bars show 95% confidence intervals.

Pre-Post Self-Confidence

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between participant self-confidence in the pre-experimental condition (PRE) and the post-experimental condition (POST). There were no outliers in the data, as assessed by inspection of a boxplot. The difference scores were approximately normally distributed, as assessed by Shapiro-Wilk's test (p = .049). Participants reported higher self-confidence in the POST condition (M = 8.37, SD = 1.31) than in the PRE condition (M = 8.06, SD = 1.44), but this difference was not statistically significant, M = .31, 95%CI [-.41 to 1.03], t(15) = .924, p =.370. These results are shown in Figure 10.

Figure 10

Participant Self-Confidence Estimates in Pre-experimental Condition and Post-experimental Condition



Note. Drop lines represent the change in self-confidence estimates provided by participants from pre-experimental condition to post-experimental condition. No line indicates the participant gave the same score in both conditions.

Discussion

The current study looked at the affects of landing difficulty (hard and easy) and spotting condition (SWT and SWOT), on gymnasts jump performance and self-confidence. We hoped to better understand how spotting provided by a coach to a gymnast, affects how intermediate level gymnasts perform a basic gymnastic skill. lFeedback and task difficulty have been found to have an impact on how athletes rate their self-confidence, with better performance occurring when receiving higher task specific feedback (Moritz, Feltz, Fahrbach, and Mack, 2000). Therefore, in this study we did not provide task-specific feedback above and beyond what was available from the touch spotting. Our hypotheses were that physical guidance in the form of SWT would improve the accuracy and precision of the jump landing and that athletes would report higher levels of self-confidence in the touch versus no touch condition. We found a significant main affect of spotting condition on participant self-confidence (p = .002).

We understand that task difficulty has been found to affect athlete self-confidence. Past research has found that participants who anticipate, or are told the task will be more difficult report lower self-confidence (Gagnon-Dolbec et al., 2019). In the current study, task difficulty was varied by asking the participants to land on either a line or inside a box, drawn on the landing surface. Landing on the line requires greater accuracy and precision, therefore this was considered the more difficult landing condition.

We predicted that the participants would perform the jump with greater accuracy and precision in the SWT versus the SWOT conditions. Overall we found this was not the case. RFD and peak force performance indicators showed no significant differences in self-confidence or skill performance between task difficulty and spotting conditions.

In a previous study, Seegmiller et al. (2003) tested a group of gymnasts and recreational athletes, measuring ground reaction force (GRF) resultant from drop landings at various heights. They observed that the gymnasts were more careless in their landings at the lower heights, resulting in no significant differences in GRF between the gymnasts and recreational athletes. It's possible that the participants in the current study did not perceive the backward jump task to be as difficult as anticipated, as the balance beam landing was simulated using line markers on a flush surface. Furthermore, in the easy landing condition it's possible that the participants were more care-free in their landing technique, however, in the current study we found no statistically significant difference, therefore it can be concluded that the participants cared about the tasks equally.

It has been found that the coach-athlete relationship has a significant affect on the athlete's psychological well-being and can affect both their physical performance as well as their state sport confidence (Kerr et al., 2015; Gagnon-Dolbec et al., 2019; Kim & Park, 2020). However, this has only been studied under conditions where the athlete and coach relationship is one that is longstanding, and the emotional and physical affects on the athletes are a result of many interactions and experiences with their coach. In this study the coach did not involve herself with the participants and any communication was directly related to the study. This lack of emotional connection between the coach and participant in this case may be a factor for why there were no significant differences in skill performance and self-confidence. However, we found a significant main affect for the type of spotting the participant received when measuring self-confidence. In line with our hypothesis, we expected the participants to report higher levels of self-confidence in conditions where they experienced SWT. In terms of self-confidence, the participants rated themselves most confident in the easy landing with SWT condition. We did not find a significant difference between PRE and POST self-confidence.

Winstein et al. (1994) highlight that the type and frequency of feedback has different affects on skill learning, skill retention and skill transfer. Their study showed that participants who received frequent physical guidance and feedback experienced poorer skill learning outcomes than those who received frequent KR feedback. However, both groups that received high frequency feedback performed equally poor in skill transfer tests. This suggests that the type of equipment used and the coaching strategies are important aspects influencing skill learning and performance. Spotting an athlete through a skill may be an affective strategy, as long as it is not done too frequently and they are provided the opportunity to attempt the skill on their own.

The presence of a coach during a sports performance could potentially lead to increased confidence in the athlete. Studies have shown that higher levels of self-confidence are associated with superior performance (Mrđa et al., 2019). The belief in one's self and abilities is a predominant factor when it comes to competing in sports. When examining the relationship between self-confidence and sport performance, past research has found that between-subjects design tasks often positively predict performance, particularly when the performance is measured or rated by the participant. Gagnon-Dolbec et al., (2019), suggest that objective measures of performance be used to avoid bias. Asking participants to rate specific and objective aspects of performance or having a separate committee or panel provide scores of the performance are some examples of how this can be achieved. In the current study we measured self-confidence by asking participants to rate themselves specifically on how they anticipated their performance outcome. The participant was made aware of the type of spot they would be receiving prior to providing their self-confidence rating, and they rated their self-confidence significantly higher when they knew they would be receiving SWT.

As the memory demands of a task increase, so do the benefits of blocked practice, while the benefits of random practice decrease. Meaning, as the performer needs to process various stimuli and information related to performing the task increases, so do the benefits of blocked practice. However, as the performer becomes more experienced by performing more and more trials of the complex task, random practice begins to become more affective (Wulf and Shea, 2002; Shea, Kohl, and Indermill, 1990). In sports such as gymnastics, this could mean that we should consider when spotting is used to teach a skill. If we are teaching a foundational motor skills it might be better to rely on lower levels of guidance to ensure skill transfer (they remember the skill). Or, we might use physical guidance less frequently than we would if the skill was more difficult.

Limitations

In the current study there were several limitations. Firstly, we did not measure the participant's body weight. Due to the sensitive nature of the study conditions, and the fact that we were also interested in measuring self-confidence, we felt that taking a measurement of body weight could have potentially negatively impacted the participant's skill performance and self-confidence. Future research may choose to collect body weight measures from participants. The current study used a within-subjects design, where participants are compared to themselves undergoing different conditions. Moreover, each participant experienced every condition and therefore the lack of body weight measure was irrelevant. Furthermore, due to costs and material availability, we were unable to construct the ideal landing surface. It may be a goal for future research to embed the force plate inside the non-flex carpet bonded foam roll (floor strip). In this study, we were not able to make alterations to the floor mat, which would require cutting the through the foam roll. We mitigated this by placing the mat on a hard concrete (rather than a typical spring floor), and constructing a wood casing covered by vinyl, to simulate a standard gym flooring.

An a priori power analysis was conducted using G*Power version 3.1.9.7 to determine the minimum sample size required to test our study hypotheses. Results indicated the required sample size to achieve 80% power for detecting a medium affect, at a significance criterion of $\alpha = .05$, was $N = 20$ for a 2-way repeated measures ANOVA. Unfortunately, we were unable to achieve an adequate sample size due to the specific nature of the study requirements (intermediate level gymnasts). Furthermore, there were building closures at the location of the study site and public health concerns lingering from the COVID-19 pandemic that may have impacted our ability to recruit participants.

Conclusion

Many sport organizations now discourage assistive spotting for beginner skills and typically only recommend spotting when absolutely necessary, or to avoid catastrophic injury. This hand-off, no touch, approach was further encouraged in response to public health and safety guidelines to prevent the spread of COVID-19 and implemented as an added safety measure when sport clubs began to re-open as lockdown measures were lifted in 2022. In this study we found there to be a significant affect of spot condition on self-confidence when performing a basic gymnastics skill. Participants were more confident when provided SWT. This shows that there is some affect of spotting for even the most basic skills, and coaches of all levels should be aware of this when teaching gymnastics elements. Safe spotting practices should be emphasized at all levels of gymnastics coaching as it may have an impact on performance outcomes.

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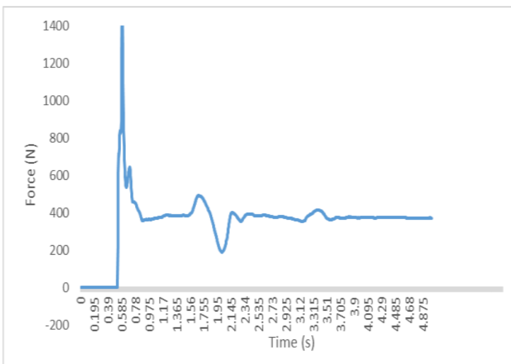
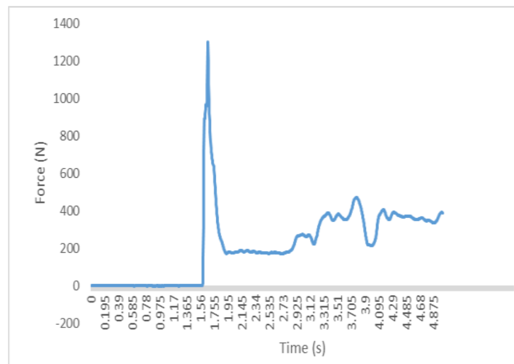
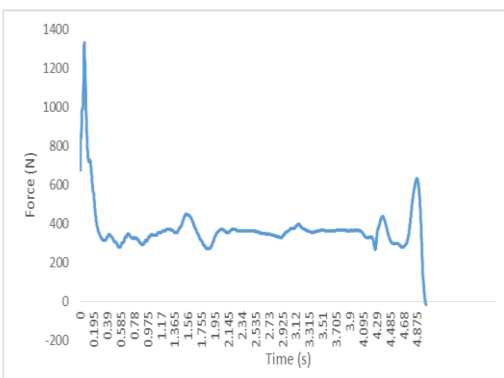
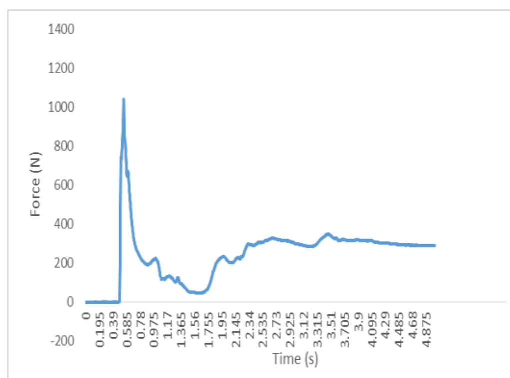
Appendices

Appendix A

Figure A1

Graphed data from a single representative participant demonstrating force over time for a single trial in each of the 4 conditions.

	Easy Landing	Difficult Landing
Spotting With Touch (SWT)		
Spotting Without Touch (SWOT)		

Appendix B

B1. Participant questionnaire

Participant First Name:
Birthdate: *E.g. January 1 1999*
Please indicate in number of years, how long you have been doing gymnastics? *E.g. 3 years*
Which CANGYM level do you feel best describes your gymnastics ability? The CANGYM level requirements are available for you to review. Please circle only one level: LEVEL 4 LEVEL 5 LEVEL 6 LEVEL 7
Please indicate in number of hours how often you do gymnastics per week. This includes training time at a club, participating in recreational or competitive program, practice and/or conditioning done at home and workouts done outside that include gymnastic elements? *E.g. 2 hours*

Appendix C

Figure C1

Setup diagram