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Reliability of squat movement competency screen in individuals with a previous knee injury

Journal:	*Journal of Sport Rehabilitation*
Manuscript ID	JSR.2017-0064.R3
Manuscript Type:	Technical Report
Keywords:	functional movement screen, injuries-and-accidents-knee-injuries, reliability

ABSTRACT

Context: Movement screens are a common method of assessing movement efficiency either against a specific criterion of segments/joint(s) motion (segmental method)**,** or a summary label of general quality of the whole movement (overall method). While not as commonly utilized within clinical practice as the segmental method, the overall method is less time consuming to perform and more reliable. **Objectives:** The aim of this study was to assess the reliability of the "overall" method approach during a squat in individuals with a previous knee joint injury. **Design:** Cross-sectional, clinical measurement. **Participants:** Two-dimensional video recordings of five squat trials were recorded for 16 participants with a history of a major knee joint injury(s) and were visually rated by three novice and three expert raters. **Main Outcome Measures:** Weighted quadratic Kappa was used to determine the intra- and inter-rater reliability of the squat movement competency screen. **Results:** Good inter-rater reliability for the expert and novice groups was observed. Intra-rater reliability was very good between analysis sessions for **one** expert rater. **Conclusions:** The overall method is a reliable method that enables allied health professionals of different levels of clinical experience to utilize a framework to assess movement quality during a squat in patients with a previous knee joint injury.

KEYWORDS: functional movement screen; injuries-and-accidents-knee-injuries**;** reliability.

INTRODUCTION

A knee joint injury may cause considerable disability, time off work and/or sporting endeavors.[1,2] To ensure an individual with a knee joint injury returns to their previous activities, it is essential for allied health professionals to employ an individualized rehabilitation program. A movement competency screen is often employed within a rehabilitation program to provide a framework to analyze an individual's quality of the movement against a specific criterion in order to identify movement deficiencies that the client needs to be improved. A key methodological issue between different movement competency screening methods utilized within clinical practice is the use of an "overall" compared to the "segmental" method approach. A large majority of research focuses mainly on the segmental method approach.[3-5] The segmental approach involves analyzing different segments and/or joints of the body during a movement such as the squat. It provides the rater with clear specific areas of focus or identification of a joint/segment angle and/or motion during the movement such as "center of the patella moving medial to the second toe".[6] Nevertheless, there is low reliability of this method, particularly regarding the inter-rater reliability of different groups of raters,[3,4] and often participants are athletes or individuals without musculoskeletal conditions of the knee joint.[6] Alternatively, the "overall" method focuses on categorizing the quality of the whole movement giving movement classifications such as acceptable movement quality, minor, moderate or marked movement dysfunction.[4] No specific guidelines are given within the overall method for the rater to classify their overall impression of an individual movement dysfunction[4], which is in contrast to the **segmental** method that provides very specific guidelines. This overall method is a more time efficient approach while still providing adequate information,[7] and has been shown to be more reliable compared to the segmental approach.[4]

While a number of movement competency screens previously reported have analyzed the movements of healthy individuals,[4,6,7] the reliability of visually rating movement quality during the bodyweight squat exercise of individuals with a previous knee joint injury using an overall rating method remains unknown.[4] Therefore, the aim of this study was to assess the reliability of a movement screen using the overall method approach during a bodyweight squat in individuals with a previous knee joint injury. It is hypothesized that this time efficient screening framework will provide (i) a good level of agreement for the expert raters compared to moderate level of agreement for novice raters, and (ii) a very good inter-trial variability during a bodyweight squat.

METHODS

Male (n = 8) and female (n = 8) participants (mean age=47.5±2.9 years; height=175±1.5 cm; mass=76±4.2 kg) **that the participants had** a history of a previous major knee joint injury were recruited. The assumed null hypothesis value of the Kappa was 0.00. Sample size was estimated for a Kappa of 0.6, an error of probability of 0.05, and a statistical power of 80%. Written informed consent was obtained from each participant prior to data collection, and all methods were conducted in accordance with Charles Sturt University Human Research Ethics Committee requirements (HREC-2012/053). Participant inclusion/exclusion criteria required that the participants had history of a previous major knee joint injury requiring orthopedic treatment and/or surgery greater than 12 months previously, regular attendees of either an exercise facility (2-3 visits per week consistently for a minimum of 2 months), and performed the squat exercise within their current program.

After performing a 5 min warm up on a cycling ergometer, participants then were familiarized with the experimental task by being given verbal cuing and instruction on how to perform the squat movement. Participants were given the opportunity to have any questions

answered on how to perform the experimental task. Each participant performed three warm-up squat movements, followed by five pain free squat trials that were filmed with two standard video camcorders (30 Hz, DCR-DVD 205, Sony).

Participants were instructed to move into the set up position of the squat by standing tall with the feet shoulder width apart and toes pointing forward. They were then encouraged to descend slowly while keeping the arms as close to the side of the body as possible, pause approximately one second at the bottom of the descent (peak knee joint flexion), and then encouraged to ascend slowly until almost completely tall (just before full knee joint extension). The magnitude of peak knee joint flexion during the squat varied (between ~90° of knee joint flexion to when thighs were parallel to the floor) depending on the individual circumstances to ensure all participants performed the squat in a pain free range of knee joint flexion motion only. This knee joint flexion range of motion is a safe squatting depth commonly reported in healthy adults,[8] is beneficial for individuals at risk of or with knee **joint osteoarthritis,[9] and** allows peak quadriceps muscular activity to occur at ~80° to 90° of knee joint flexion.[10]

To assess the intra- and inter-rater reliability of the squat movement competency screen, each rater viewed the sagittal and front plane videos of each participant three times before the rater made a decision on the individual's squat movement competency score (~10-15 minutes). To minimize any memory bias, a minimum 2 week washout period between each rating session' was ensured, and each **session's** videos were viewed by the participant in a randomized order. In each session, each rater viewed the video of five repetitions of the participant performing the squat once in the frontal and sagittal planes, with the option to viewing the sagittal plane an additional two times before having to make a decision on their squat movement competency score. Movement competency scale (Appendix 1) requires the

rater to score the squat movement in a numerical, categorical number (0-10) based on criterion of their movement competency.

The raters were divided into two groups according to their level of professional experience in the field/years of clinical experience. EXPERT group (*n= 3*) defined as >5 years field experience (*n*=1 experience using this study's tool). NOVICE group (*n= 3*) defined as <5 years field experience, no previous (*n* =2) or <1.5 months (*n* =1) experience using this study's tool. As these novice raters had none or less than 1.5 **months** of experience using this study's tool, they received an educational tool on how to perform the movement competency functional screen via a 5 min PowerPoint presentation (Appendix 2).

A weighted quadratic Kappa was used to determine the intra- and inter-rater (NOVICE compared to EXPERT) reliability using the statistical package MedCal (v13, MedCal Software, Osten, Belgium). Strength of agreement of the weighted Kappa was categorized as poor = <0.00, slight 0.01-0.20, fair 0.21-0.40, moderate 0.41-0.60, good 0.61-0.80, and very good 0.81-1.00.[11]

RESULTS

Good inter-rater reliability was displayed between the three EXPERT raters and between the three NOVICE raters (Table 1). For one expert rater, very good intra-rater reliability between two rating sessions was observed. Percentage agreement was 48% for NOVICE and 54% for EXPERT rates, and 81% between sessions.

DISCUSSION

In agreement with previous research,[4] the overall approach method utilized in this study showed good inter-rater reliability. The advantage of utilizing this overall method approach in comparison to the segmental method is that it is more practical for real-time analysis in clinical settings where simplicity is best. Additionally, the overall method is likely

the most time efficient approach, while still providing enough information in a clinical environment.[4] It took the raters ~10-15 minutes to complete **ratings** for all 16 participants performing five squat movements in the frontal and sagittal planes, with the option to go back and review the five squats in the sagittal plane another two times (20 squats in total). This study's tool in a clinical setting will provide the rater with an abundance of exposure to the squat movement, allowing the rating of the squat to be performed using the overall approach. This highlights the tool's extremely time efficient use within clinical settings. Based on one expert's very good strength of agreement of the intra-rater reliability, this scale is reliable when used repeatedly by the same individual to assess movement competency during a squat in individuals with a history of a major knee joint injury.

It should be noted that all raters within this current study were employed by one company, across two different facilities that utilize this method with all clients with a history of a major knee joint injury. This contributed to the good inter-rater strength of agreement that was observed for both groups, indicating it is a reliable method for allied health professionals with different years of clinical experience. Acknowledging this study's limitation of the raters being employed by one company, the use of two separate facilities suggest that employing this tool in different companies or facilities is likely to have no or minimal effect on this tool's good inter-rater strength of agreement.

An interesting observation during this study was that category 7 of the movement competency scale (postural/functional position lost) was the most commonly identified category by raters that lead to the breakdown in performance of the squat. A limitation of using the "overall" method was that it did not record the specific error(s) that led to the postural/ functional position being lost during the squat. Nevertheless, Appendix 2 provides the rater with clear, specific areas of focus during the movement such as "Is there any lateral dropping of the hips during the squat?" This will allow the rater to classify the overall

movement quality, and still **provide** information to the clinician on specific area(s) to focus within an individual's rehabilitation. This commonly identified category 7 error was often attributed by the raters to the individual transferring their distribution of body mass to their un-affected side, a commonly observed error in an individual with a previous knee joint injury, despite undergoing previous rehabilitation.[12] This error was not attributed to pain, as participants reported no pain during the execution of the squat. This movement error suggests that the individual may have developed compensatory movement patterns during the initial rehabilitation period, or even prior to the injury. It is likely that this compensatory movement may be due to a physical weakness, while trying to decrease the amount of body mass that the affected lower extremity must support. If individuals with **a** previous major a knee joint injury regularly perform this aberrant change in a movement pattern, the movement strategy will become part of the brain's program associated with that movement.[5] These **findings** have strong practical implications if the change in movement pattern persists, outlasting the painful episode, because movement quality of the squat and overall athletic performance may be sacrificed in the long term.

Using an overall approach method to assess the quality of movement during a squat in individuals with a previous major knee joint injury is a reliable and time efficient method for allied health professionals with different years of clinical experience and between sessions. This provides allied health professionals a reliable tool in clinical settings to assess changes in bodyweight squat movement competency in patients with a knee joint injury.

ACKNOWLEDGEMENTS

To Mr John Felton, for inspiring Mr Mark Liberatore to investigate the field of functional movement screening and for providing him with The Exercise Clinic Movement Competency Scale, to investigate its reliability. Thank you also to the staff at The Exercise

Clinic and The EY Gym for agreeing to take part in the study and assisting in the collection of data.

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CAPTIONS

Table 1 Inter- (novice vs. expert) and intra (inter-trial variability) rater reliability for squat movement screen with **a** history of previous knee joint injury.

Appendix 1 Squat Movement Competency Scale.

Appendix 2 PowerPoint presentation on how to perform the movement competency functional screen.

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205 **Table 1** Inter- (Novice vs. expert) and intra (inter-trial variability) rater reliability for squat
206 movement screen with **a** history of previous knee joint **injury**.

	Mean ± SD	Weighted Kappa	Standard Error	95% CI		Strength of Agreement*	Percentage Agreement
				Lower	Upper		
Novice							
Novice 1 vs. 2		0.667	0.120	0.431	0.903		44%
Novice 2 vs. 3		0.798	0.062	0.676	0.920		50%
Novice 1 vs. 3		0.698	0.117	0.468	0.928		38%
Mean	4.1±1.2	0.721	0.100	0.525	0.917	Good	44%
Expert 1 vs. 2		0.609	0.128	0.358	0.860		50%
Expert 2 vs. 3		0.810	0.122	0.571	1.000		75%
Expert 1 vs. 3		0.644	0.113	0.423	0.865		38%
Mean	4.3±1.1	0.688	0.121	0.451	0.908	Good	54%
Intra-reliability							
Day 1 v 2	4.0±1.2	0.931	0.039	0.854	1.000	Very good	81%

*Strength of agreement of the weighted Kappa was categorized as poor = <0.00, slight 0.01-0.20, fair 0.21-0.40, moderate 0.41-0.60, good 0.61-0.80, and very good 0.81-1.00.

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Appendix A

Squat Movement Competency Scale©

The Exercise Clinic
Medically Supervised Exercise

Phases	Scale	Progression
Phase 1 – Set Up	0	*Setup:* unable to understand instructions or cues.
	1	*Setup:* able to understand instructions/cues but unable to perform postural/functional setup for the initiation of the movement.
	2	*Setup:* able to perform postural/functional setup. *Execution:* unable to initiate the movement without losing postural/functional position required.
Phase 2 – Execution	3	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement but becomes mechanically unstable and/or required postural/functional position is lost at <50% of movement.
	4	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement but becomes mechanically unstable and/or required postural/functional position is lost at 50% of movement.
	5	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement but becomes mechanically unstable and/or required postural/functional position is lost at >50% of movement.
	6	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement remain mechanically stable while maintaining required postural/functional position throughout the full movement with active conscious effort.
Phase 3 – Function	7	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement remain mechanically stable while maintaining required postural/functional position throughout the full movement. *Function:* can execute without conscious effort.
	8	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement remain mechanically stable while maintaining required postural/functional position throughout the full movement without conscious effort. *Function:* can execute variations of the full movement.
	9	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement remain mechanically stable while maintaining required postural/functional position throughout the full movement without conscious effort. *Function:* can execute loaded variations of the full movement.
	10	*Setup:* able to perform postural/functional setup. *Execution:* able to initiate the movement remain mechanically stable while maintaining required postural/functional position throughout the full movement without conscious effort. *Function:* can execute variations of the full movement to maximal loading. Execution doesn't breakdown before muscular failure.

The Exercise Clinic Functional Progression Scale

AN EASY TO USE GUIDE FOR THE EXERCISE PHYSIOLOGIST AND EXERCISE SPECIALIST

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The project

- The research project I am conducting is titled: “Validity and reliability of functional movement screen criteria of the squat movement in individuals with previous knee injuries”
- Its purpose is to assess the reliability of The Exercise Clinic (TEC) Functional Progression Scale as a functional movement screening tool
- The validity of the squat as a reliable functional movement test in individuals with a previous knee injuries will also be evaluated
- TEC and The Gym (Ernst & Young) were screened and potential participants contacted and recruited.
- From a group of 10, 6 were chosen to take part in the study.
- The participants were instructed to perform five body weight squats and this was filmed from both a front and side view.
- The instructions for the squat included trying to squat down to an angle of 90 degrees pain-free which is considered to be safest for those with previous knee injuries (Liu, Chou & Liaw, 2010)
- As a rater you will be required to view the footage given to you and rate the movement of each individual with the help of TEC Functional Progression Scale.

The bodyweight squat: what I am looking for?

Postural/ functional set up

- Standing tall with spine in neutral position throughout
- Gaze forward
- Knees over toes and slightly bent
- Feet facing forward
- Hips facing forward (no tilt)

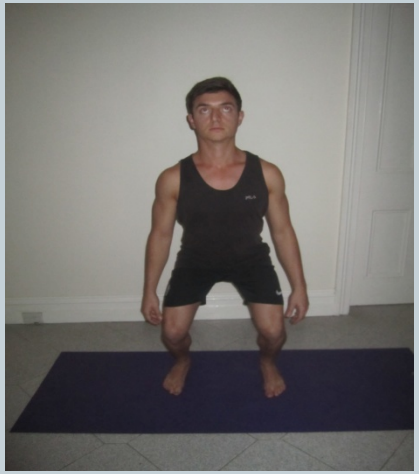
(Kritz, Cronin & Hume, 2009)

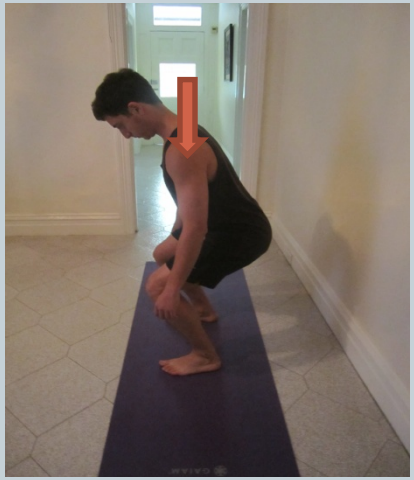
Mechanical instabilities

Head/ neck position

-Is the head flexed forward or extended back?

-Is there any side to side movement of the head or neck?





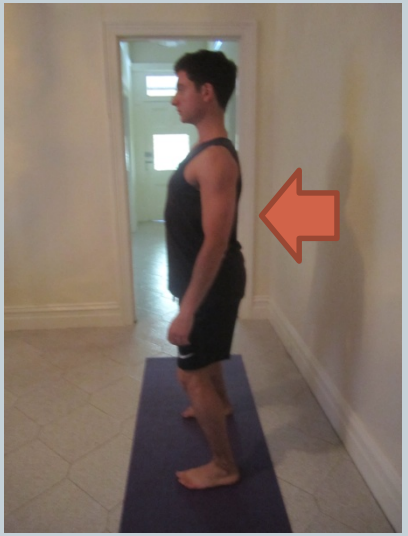
Mechanical, postural & functional positioning

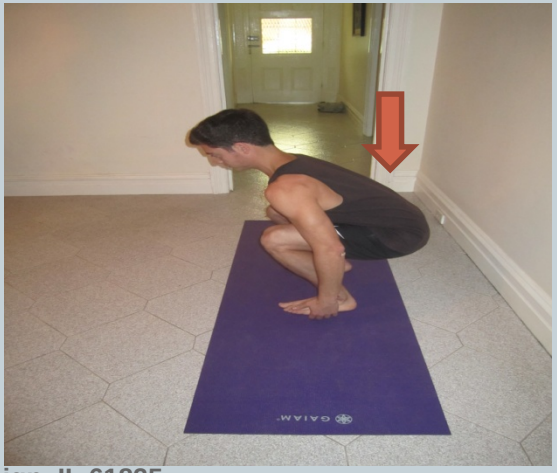
- Thoracic and lumbar spine positioning

- Is there any excessive thoracic or lumbar extension or flexion in the spine prior to performing the squat? →

- Are the scapulae abducted?

- Is there any excessive extension or flexion in the thoracic or lumbar spine during the squat? →





The lower extremity in focus

- Hips

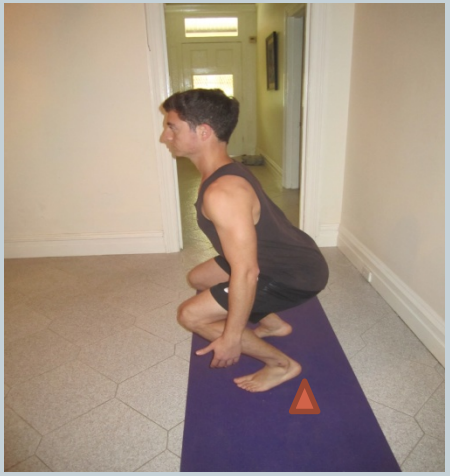
- Is there any mediolateral rotation of the hips during the movement ?

- Is there any lateral dropping of the hips during the squat? →

- Feet/ ankles

- Is there any supination/ pronation of the feet?

- Do the heels lift off the ground? →

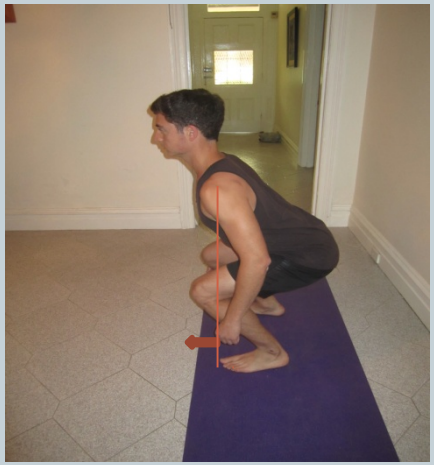


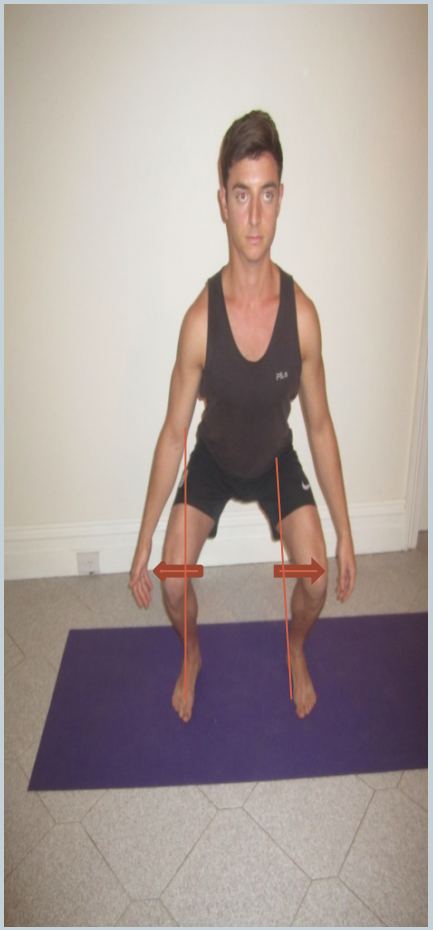
The knees

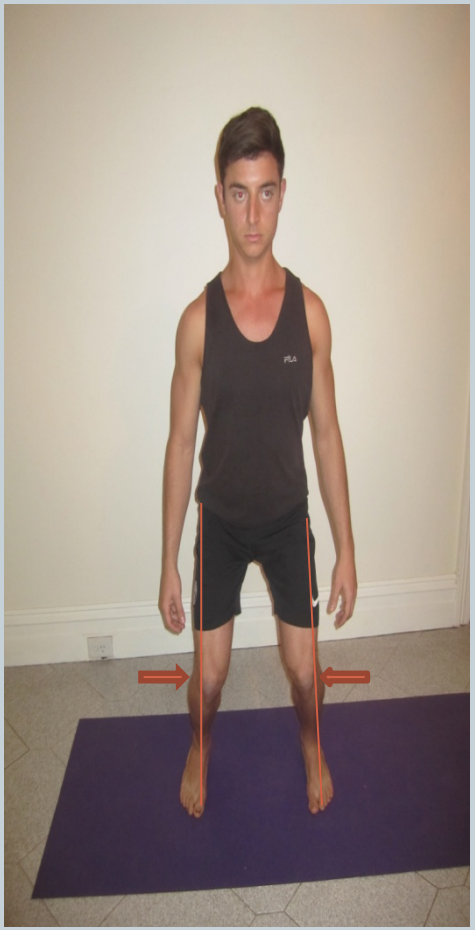
- Knees

- Alignment inside (knee valgus) or outside (knee varus) hip →

- Are the knees in front of the toes at the bottom of movement?







The Scale

- The Exercise Clinic (TEC) Functional Progression Scale is a tool we can use to screen and assess functional movements and exercises.

- The use of the scale provides a time efficient and effective screening process which will enable us as practitioners to better understand what we are looking for in the visual, qualitative assessment of a particular screening exercise.

- The scale (0-10) has three distinct phases:
  - Set up
  - Execution
  - Function (refer to next slide)

- It is expected that the majority of individuals filmed will be in the 0-6 category

- Please read the following few slides carefully as they will provide you with a better understanding of the tool

The Exercise Clinic Functional Progression Scale©

The Exercise Clinic
Medically Supervised Exercise

Phases	Scale	Progression
Phase 1 – Set Up	0	*Setup:* unable to understand instructions or cues.
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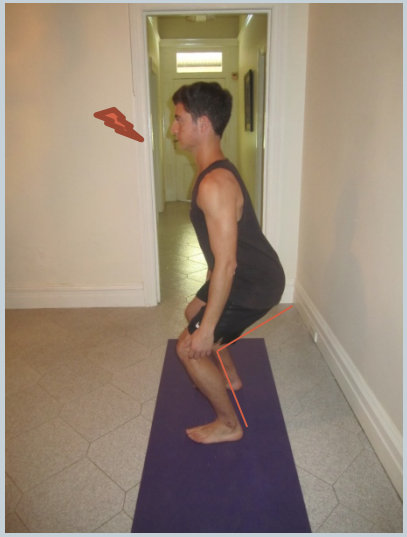
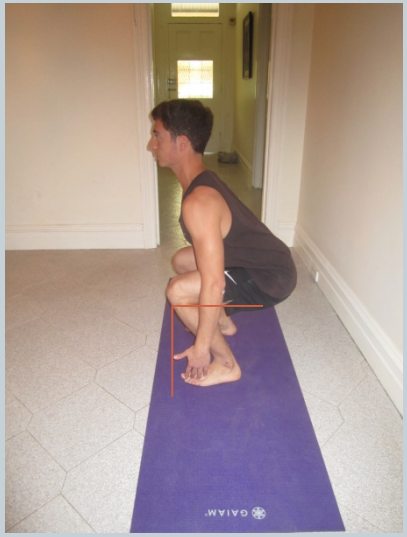
Phase 1- Set up

- 0 = An inability to understand instructions + cues →
- 1= Able to understand the instructions but unable to perform postural/ functional set up to initiate squat
- Each of the research participants are already performing a bodyweight squat or similar movement in their current exercise regime and will therefore be expected to set up correctly for the movement
- 2= Able to perform set up but unable to initiate movement without losing functional position e.g. immediate lateral tilting of pelvis

Phase 2- Execution

- 3= < 50% movement is considered as an angle at the knee less than 45 degrees → before a mechanical insufficiency or the postural/ functional position is lost e.g. excessive lumbar extension
- 4= 50 % of movement is considered as a squat which reaches a depth of 45 degrees before any obvious movement discrepancies. Is the highlighted picture an example of this?
- 5= More than 50% of movement would be between 45-89 degrees range.
- 6= The full squat movement is a squat which reaches a depth of 90 degrees or parallel to the floor with the thighs





Phase 3- Function

- A score of 7 indicates that the individual is able to initiate the squat movement and remain mechanically stable while maintaining required postural/functional position throughout the full movement without conscious effort.

- Each of the research participants were educated on how best to perform the squat movement prior to the filming during a practice trial (3 squats)

- It is therefore presumed each of the participants were actively making a conscious effort to perform the squat as directed, therefore eliminating number 7 as a scoring option.

Thank you !

- Thank you for taking your time in reading this presentation.
- It is now time to watch each individual participant perform the bodyweight squat a total of five times.
- You will be afforded three views of each individual before providing a final score.
- Thank you for agreeing to participant in this study. Your efforts and expert assistance have been of great assistance.
- Happy squatting!

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