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TESTING THE RELIABILITY OF A FIELD SCREENING TOOL TO IDENTIFY MODIFIABLE RISK FACTORS IN ACL INJURY FOR YOUNG WOMEN

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The objective of this Bachelor thesis is to test the reliability between two testers of a field screening tool to identify modifiable risk factors in ACL-injury for young women. This thesis was done in cooperation with physiotherapy students in Satakunta University of Applied Sciences. The practical part of this thesis was performed in Satakunta University of Applied Sciences, where two third year students were screening the injury risk for anterior cruciate ligament injury for three female first year students. The screening was performed by using a field screening tool to identify modifiable risk factors in ACL injury for young women, which is adapted from Myer et. al (2011) and Stroube et. al (2013).

The aim of this Bachelor thesis is to assess the consistency of the test results under different conditions and testers. The aim of the thesis raised two research questions: (A) Does the subjects have flaws in movement patterns based on the field screening tool? (B) Is the field screening tool reliable between two testers testing the same subjects?

Theoretical part of the thesis cover risk factors and injury mechanism for ACL injury for females and what reliability in quantitative research includes. A brief background of the field screening tool is presented in theory. The test results cover the outcomes of this thesis.

Based on the assessment, two testers reported 29 movement flaws together in total, occurring once or more. Average percent of agreement (PEA) between to testers for three subjects was 66%. The kappa measure of agreement was 0,32, referring for a fair agreement.

CONTENTS

1. INTRODUCTION

It is a necessity in research to successfully guide evidence-based recommendations to practitioners, so they can implement high level practice which is evidence-based. In addition, researchers should concentrate helping practitioners by focusing on future research. (MaCall et al, 2015)

In the sporting world, physical performance tests are implemented at multiple levels as a part of pre-season screening. As an advantage of the physical performance testing (PPTs), they are easy to implement, demand a small amount of expertise and are not time consuming. In addition, they do not require expensive equipment and the testing can take place in various situations and settings. These tests should provide some key measurements such as validity and reliability. Validity explains if the measure/test is testing what it aimed to test. The latter, reliability, provides information of the amount of free error in the test. Whether PPTs in general produce valid information is under some debate, and furthermore if the measured properties are useful to be used as outcome measures is under some claim. PPTs are largely used by a wide array of professional to discover information of symmetries and asymmetries, rehabilitation process and injury risk. (Hegedus et al. 2017)

Pilsky et al (2006) found that the accuracy of recognizing risk of injury may be increased with a test assessing multiple aspects of function simultaneously, such as balance, strength and range of motion. Hence a reliable and valid test to measure these multiple aspects of function is in demand. (Minick, 2010)

2. RISK FACTORS AND INJURY MECHANISMS FOR ACL-INJURY

Major improvements have lately been made in understanding the mechanisms involving in non-contact anterior cruciate ligament (ACL) injury. Majority of ACL injuries have minimal or no contact. In athletes, females tend to sustain a two- to eightfold greater rate of injury than male athletes. Videotaping analyzes reveal significant differences in average leg and trunk positions during injury compared with control subjects. A thorough understanding of risk factors and forces connected to non-contact ACL injury should lead to development of preventive actions for this devastating injury. (Boden, Sheehan, Torg, Hewett. 2010)

Approximately three quarters of ACL-injuries are noncontact injuries. To optimize prevention strategies, it is critical to understand the injury mechanism. Multiple theories and risk factors have been introduced to explain the injury mechanism of a non-contact ACL-injury, such as impingement on the intercondylar notch, contraction of quadriceps, the quadriceps-hamstring force balance and more lately, axial compressive forces on the lateral aspect of the joint. Multiple explanation for the increased risk for female athletes has been suggested, including increased knee valgus or abduction moments, generalized joint laxity, knee recurvatum, size of ACL and the hormonal factors of estrogen on ACL. (Boden et al. 2010)

In a typical ACL injury, the knee is in a rotation motion and the foot is in contact with the ground. This loads the ACL and can cause a rupture, which's severity can differ from few fibers to total rupture. Furthermore, a heavy impact to the knee can cause a rupture. In these cases, the injury usually affects menisci and other ligaments. Sharp pain during the injury and swelling post-injury are signs of a rupture. (Walker 2014, 192)

2.1 Biomechanical and neuromuscular factors

Focus in the ACL-injury prevention has focused on identifying the risk factors such as biomechanical and neuromuscular factors. Majority of the ACL injuries take place in a non-contact situation. In these situations, it is found that a non-contact ACL injury for female athletes shows a combination of reduced electromyography (EMG) pre-activity in semitendinosus muscle along with increased EMG pre-activity of quadriceps muscle vastus lateralis. This leads to increased EMG pre-activity difference. Hewett et al. listed primary predictors of non-contact ACL injury to be excessive knee valgus angle and high knee valgus moment arms during drop jumps. These findings propose motor control patterns to play a role in predicting these injuries. (Zebis et al. 2015)

The risk profile for a traumatic knee injury such as ACL injury appears multifactorial as described in the literature. For example, greater knee valgus, high knee valgus loads and medial knee placement are factors connected with ACL injury. Credible explanations for higher ACL injury rate in females than males have been proposed, that is, worse neuromuscular control in cutting maneuvers and lower hamstring to quadriceps torque ratios. (Myer, Ford & Barber, 2009) However, the role of lower extremity muscle strength as a predictive factor for traumatic knee injury remains relatively unknown and existing studies report contradictive results. (Augustsson & Ageberg, 2017)

Augustsson & Ageberg (2017) conducted a case-control study for 225 athletes (40%female) in sport senior high schools in Sweden. Inclusion criteria for the study were male and female athletes, aged 15-19 and competing in ice hockey, handball, soccer, alpine skiing, basketball or foorball.

A repetition maximum (1RM) barbell squat test was used to measure muscular strength of hip muscles (quadriceps, the gluteus muscles, hamstrings and adductors). The participants were asked to record traumatic knee injury during their high school period. Traumatic knee injury was prescribed as an injury to menisci, ACL, other ligaments, fracture or cartilage damage. Majority of injured females were in the weak median group (n=22) compared with the strong median group (n=4) (p=0.0001), while there were no differences between the weak median (n=13) and strong median (n=13)

groups for males (p=0.830). The injury prevalence was higher in weak females than in weak males. (Figure 1.)

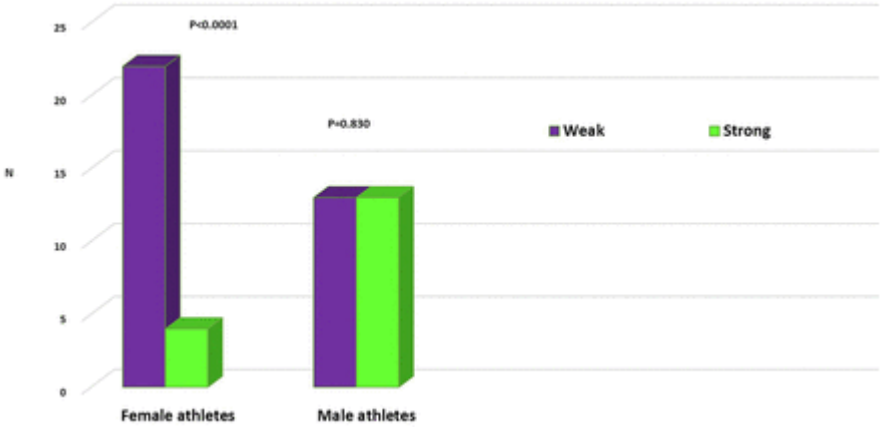


Figure 1. Number of injured athletes with an ACL injury in strong-median versus weak-median groups of female and male athletes. (Augustsson & Ageberg, 2017)

These finding indicate that weaker lower extremity muscle strength indicates traumatic knee injury in young female athletes. In support of this, higher lower extremity muscle strength was associated with lower injury rate. Association with lower muscle strength and injury rate was confirmed for females but not for males, there can be various explanations for this difference by gender. (Augustsson & Ageberg, 2017)

2.2 Female ACL noncontact injuries

Female athletes who participate in sports such as basketball, soccer and volleyball have a to-to eightfold higher rate of ACL injury than male athletes. Predominant risk factor for ACL injury in female athletes is knee abduction. (Hewett et al. 2005) Previous ACL reconstruction is a risk factor for subsequent injury on the contralateral knee. (Shelbourne, Gray & Haro, 2009) Boden et al. (2009) studied ACL injury by descriptive and analytic videotaping and found male athletes usually injured durin strenuous jumping maneuvers. Female athletes were commonly injured during a simple deceleration maneuver. In addition, female athletes tend to have greater knee abduction moments during landing when compared to male counterparts. This is considered as one primary predictors of future ACL injury risk. (Hewett et al. 2005)

Zazulak's et al (2007) prospective study reported core proprioception deficits and excessive lateral trunk displacement to be strong predictors of knee, ligament and ACL injury risk in female athletes. Nonetheless, in male athletes these did not appear as strong predictors of injury. In the report it was indicated that inadequate neuromuscular control of the trunk in the coronal plane may increase abduction torque at the knee for female athletes, exposing to ACL injury. Knee abduction load can be increased from 29% to 60% by altering the arm position relative to the center line of the body. (Chaudhari & Andriacchi, 2006) In addition, deficits in proprioception in female subjects have been demonstrated to follow quadriceps-dominant activation at landing, which reduces the timing in hamstring activation, this is not seen in male counterparts. (Hewett et al. 2006)

3. RELIABILITY

The word reliability is connected to compare one item/person with another. (Mishra & Sandilya 2009, 1) In other words, it assesses consistency of the test results meaning the repeatability of it. A study is considered reliable and accurate, when a repeated measurement results in exactly same results without depending on the researcher. (Vilkka 2005, 161; Hirsjärvi et al. 2005, 216.) It cannot be compared precisely with respect to human behaviour, but it can give an indication if one person is more reliable than the other. Measuring the reliability of human behaviour or function can be easier. For example, measuring the punctuality of individuals for attending their work place with or without failure can indicate their reliability in performing a specific task. (Mishra & Sandilya 2009, 1.) The reliability of a study should be assessed already during the study. Furthermore, aspects affecting on the reliability of a study may be contemplated after the study as well. As an example, a similar factor can be measured with two questions in a way, that their correlation factor is calculated. Results of a study cannot be generalized outside it, meaning that the test results are always valid in given time and place. (Heikkilä 2004, 30, 187.

Reliability of research in a quantitative study is measured by assessing the studies validity and reliability. Qualitative research proposes different method in assessing the reliability. Reliability explains the consistency of the results. It reveals the ability of a test to produce non-random results. One example of testing the reliability, is to measure assessment tool in different environments. If the results occur similar, the assessment tool is considered as reliable. It is recommended to use measurement tools which are tested and standardized. On the other hand, the age and contextuality of the measurement should be critically assessed. Health care and nursing is developing constantly, which questions the use of measurement tools over 20 years old. (Kankkunen & Vehviläinen-Julkunen, 2009, 152,153)

3.1 Objectivity in quantitative research

A research paper is a researchers' interpretation of specific literature and sources. A researcher is demanded to obey both linguistic and methodological objectivity.
For quantitative research, a important criteria of objectivity is reached when another researcher is able to repeat the study from similar premise. In methodological questions, the objectivity includes honestly selecting references and sources which are interpreted thoroughly and in addition, references include material which are proposing disagreement from one's own understanding. The researcher as a writer must control and pay attention to his language and personal opinions while maintaining the topic in the center. Rational and factual text with similar choice of words permits the reader an opportunity to free interpretation and inference. (Hirsjärvi, Remes & Sajavaara. 2009, 309, 310)

Objectivity in research is divided into two parts. These are test results as perception and dispersion and as interpretation of the results. During the research process an aim is to target as an objective study as possible: objective research process and results. Alkula, Pöntinen, Ylöstalo 1995, 297, 299.) Objective research process and results are contributed by a distant relationship between examiner and examinee during the process and the littlest influence by interview or questionnaire to the given answers and test results. For example, when an examiner is using post mail or collect the data

online, he never meets a subject in person. In phone or visit interviews an examiner meets the examinee in person or gets acquainted by voice, nonetheless the distance to the examinee maintains. (Vilkka, 2007, 16.)

In turn in interpretation the results are placed in an external frame of reference. In this way faculties, models, theories and research traditions by the examiner are affecting in the interpretation. The results are possible to be interpreted in multiple ways, depending on the frame of reference they are placed in. (Alkula et al. 1995,297, 299)

3.2 Inter-rater reliability

In a scientific study or experiment, classifying subjects and items into previously defined different categories is a common phenomenon. The reliability of this process can be formed by having two individuals or testers to individually perform a classification with the same objects. This process will result in an inter-rater reliability experiment, where two categorizations are generated from the same objects. The amount of agreement from the categorizations is what is referred as the inter-rater reliability. If inter-rater reliability is high, the testers can be used interchangeable without it affecting the results of the study or experiment. Interchangeability of testers authorized the importance of inter-rater reliability. When interchangeability is secured, subjects can be tested with confidence by all testers. This concept will be valuable to those who are worried about their data being affected due to a broad number of testers and not by the subjects. (Kilem 2014, 4) This concept is useful because human examiners may not interpret answers or phenomena the similar way: observers may not agree as how well or poorly certain response or material reflects knowledge of the construct or skill being tested. (Phelan & Wren. 2005)

3.3 Cohen’s Kappa

The kappa statistics is commonly used in testing the inter-rater reliability. Measurement of the extent in which the testers (data collectors) report the same score of the same variable measured is called interrater reliability. Traditionally this has been

measured by percentage agreement, where the number of agreement scores is divided by the total number of variables.

However, in 1960, Jacob Cohen questioned the use of percent agreement due to its inability to account chance agreement. He introduced Cohen's Kappa, which he developed to account for the possibility that raters guess on at least one variable due to uncertainty. The kappa statistic can range from -1 to +1. Any results where the kappa is under 0.6 should be placed with little confidence. It is frequently used in assessing interrater reliability, but it has its limitations. The limitations and critics question the levels of kappa which should be acceptable for health care research. Its interpretations may be too lenient due to scores being as low as 0.41 might be acceptable.

Percent agreement and Kappa are compared, and levels of both should be demanded in health care studies. Both kappa and percent agreement have their limitations and strengths. The Kappa takes the possibility of guessing in account, but the assumptions it makes about tester independence are not well supported and it lowers the agreement excessively. On the other hand, percent agreement does not take guessing into account and it is considered as its limitation. Apart from this fact, the percent agreement is easy to calculate and interpret. (McHugh, 2012).

4. VALIDITY

Flaws are aimed to be avoided in research, but still the reliability and validity fluctuates. Reliability of a study explores the repeatability of the results. Another measure connected in assessing a study is called validity. Validity is the extent of a study method or a measuring tool to measure what it is purported to measure. In other words, validity measures how successfully a survey has operationalized theoretical concepts into spoken language and how the concepts are transferred to the measure. (Vilkka, 2007, 150). Measures and study methods do not always correspond to the reality, in

which the researcher is imagining to study. As an example, if participants in a questionnaire misunderstand the questions and answer based on their view which differs greatly from the researcher's original view, who then processes the answers based on his views. This will result as the answers not being valid. (Hirsjärvi, Remes & Sajavaara, 2009, 231-232) As another example, if a weight measuring scale is wrong by 4 kilograms, it can be specified as reliable since the scale is wrong the same number of kilograms each time. However, it cannot be specified as valid since it does not display the actual weight of the item. (Website of Research Methodology, 2017).

4.1 Overall reliability

In research, reliability and validity together construct study's overall reliability. Overall reliability of a conducted study is considered good, when the sample presents general population and measurement contains as little random errors as possible. This can be assessed, for example, by a follow-up measurement. (Heikkilä 2004, 185; Uusitalo 1991,86.).

Overall reliability can be improved during a research process for example with following factors:

- Research the factor, which was aimed to be researched.
- Population of the study is well-grounded
- Sampling of the population is defined carefully. Sampling must include all the attributes of the population and its size is adequate to be researched.
- Measurable factors are explained precisely and unambiguously.
- Method for analyzing is chosen based on its ability to produce significant data for the topic being researched.
- Opinions and attitudes are clear ensembles.
- Questions are by as concrete as possible by their content
- Sampling method is suitable for the sample group
- Study process is implemented with honesty and care.

(Vilkka, 2004, 152-153.)

5. FIELD-SCREENING TOOL FOR ACL

Theakston & Motto (2016, 33) adapted the field screening (FST) from the tuck jump assessment proposed by Myer et. al (2011) and Stroube et al. (2013) The FST aims to recognize young 12-25 years old female athletes at risk of ACL injury. It is designed to community and school sport setting.

The FST includes a tuck jump test and assessment to identify subjects with high risk movement pattern in jumping and landing. The test movement, a tuck jump is a relatively challenging maneuver and through repeated attempts it is likely to reveal movement or control flaws. These flaws are known to contribute to ACL injury and are modifiable through exercise.

The tuck jump test is fast to administer and suitable for testing big groups or teams in short time. A physiotherapist can perform the testing in a clinic or field setting. The jump zone is a 40cm x 40cm square, which is marked by tape on the floor. Digital cameras are set up to frontal and sagittal plane to record. Floor surface should not be slippery, but even and firm. A short warm-up is guided to the subjects. In the beginning of the screening, a brief interview is conducted to receive information personal information, health status and contraindications for testing. The examiner guides a basic tuck jump technique to the subject. The jumps are assessed by using the Field Screening Tool Booklet. (Appendix 1) The test is assessed by examining instances of 12 technique flaws during peak, initial contact and landing phases of all 10 tuck jumps. These 12 flaws include: (1) knee extension on landing, (2) foot contact not simultaneous in landing, (3) knee valgus; one leg, (4) knee valgus; two legs, (5) lateral trunk movement at peak, (6) knees not up high enough at peak, (7) too narrow foot placement, (8) not landing in target square, (9) limited change in 35 flexion, (10) Too wide

foot placement, (11) Flat footed landing, (12) Feet not parallel front-to-back. The testers utilized FST-booklet in the screening. (Appendix 2)

5.1 Physical performance tests for knee function

Hegedus et al. (2017) published a systematic review of measurement properties and their correlation with injury. Their objective was to determine the relationship between physical performance tests (PPTs) for knee and injury in athletes aged 12 years to adult. The tests included hop tests and after inclusion and exclusion criteria six PPTs were complied with the best evidence synthesis. These were: one leg hop distance (single and triple hop), 6-meter timed hop, crossover hop for distance, triple jump and single leg vertical jump. Above mentioned tests have been significantly studied and therefore information of their reliability, agreement, validity and responsiveness are known. The one leg hop is the most studied for these six measures. Hegedus et al (2017) concluded conflicting and unknown evidence for PPTs for knee and urged more research on this area, hopefully resulting in concrete evidence on whether PPTs could be used as a meaningful outcome measure.

6. AIM AND OBJECTIVES OF THESIS

The aim of this Bachelor thesis is to test the reliability between two testers of a field screening tool to identify modifiable risk factors in ACL-injury for young women.

The objective of this bachelor thesis is to assess the consistency of the test results under different conditions and testers.

7. METHODOLOGY

Research is about decisions and options all the way the point, where the finished article is sent to be evaluated. The researcher is responsible from the decisions and options, and they can be problematic in the process. We are talking about options, when it is discussed what is studied, what kind of literature is collected or which approach to be used. Rarely there is a "right" answers to these questions, however, these decisions and options are important. (Hirsjärvi, Remes & Sajavaara, 2009, 123.).

7.1 Subjects

Subjects for this thesis were chosen from the international physiotherapy students from Satakunta University of Applied Sciences. The first-year students were asked to inform if they have interest in participating in a thesis to identify risk factors for ACL-injury. The inclusion criteria consisted from age being under 25, female gender and having background in team sports which include jumping, pivoting and sprinting. In addition, physiotherapy students were chosen as the clients due to generally having active life-style and history in team sports. Three subjects were chosen based on the criteria, all the subjects were under 25 years of age, average age being 20, did sports three of more times a week and had history in team sports.

7.2 Testers

A general proposal was sent to second year physiotherapy students to achieve information of participants interested in taking part as a tester for the thesis. Two physiotherapy students showed interest in taking part in the process and volunteered for the thesis. Since aim of the field screening tool is to provide an effective and evidence-based screening method for health care professionals working with athletes, and to perform the screening with low cost in a community setting, physiotherapy students are a suitable group to perform the tests. Reliability of the field screening tool is tested by comparing the results of two different testers.

The testers were educated on the field screening tool in a similar way. The assessment booklet was sent to the testers before-hand for familiarizing themselves to the topic. Seven days before the screening, a 1-hour meeting was set to discuss the assessment tool step by step. This meeting consisted of educating the testers on how to read and implement the FST. Aims for the meeting was to a) understand the background of FST, b) learning to prepare the setting for the assessment, c) learning to execute the assessment, d) learning to use the video cameras, e) learning to recognize movement flaws presented and f) learning to fill in the tuck jump assessment test formula.

7.3 Implementation

The screening took place in a physiotherapy classroom in Satakunta University of Applied Sciences. The screening was conducted on three subjects in total. All subjects were tested on consecutive days at the same time of the day and in the same order.

Testers independently prepared the classroom, digital cameras, tape and a field screening booklet. With each of the subjects, the tester implemented the screening based on the instructions written on the booklet. With each of the subjects, a brief interview, demonstration and videotaping were conducted in similar manner.

The interview consisted from background information, health status and contraindications for testing. The testers demonstrated a basic tuck jump technique to the subjects individually. In addition, verbal cueing was given by asking subjects to start from athletic starting position, jump high, bring knees up, land softly on the balls of the feet, bending knees, no pause between jumps and try to land in the marked jump zone.

Following the videotaping of all subjects, the tester independently used the two-dimensional digital camera records in slow motion to observe specific flaws and to fill the points in to the field screening booklet. Video records from frontal and sagittal plane were used to observe the flaws. Testers used page number five in the FST-booklet as guidance to recognize movement flaws. Page five in the booklet consists

from 12 movement flaws with a photo and explanation. Testers assessed the videos by selecting one of these flaws and played the tape to assess if the flaw was present and how many times it occurred.

8. RESULTS

Two research questions for this thesis were: Does the subjects have flaws in movement patters based on the field screening tool? If so, are the test results reliable between two testers? Test results are presented in charts which are divided into four categories according to different dominance dysfunction-parts.

These parts are ligament dominance dysfunction, quadriceps dominance dysfunction, leg dominance dysfunction and trunk dominance dysfunction. Each of the four dominance dysfunction parts include three different specific flaws, which are presented in the charts. The charts present number of occurred flaws ass by the testers. According to the field screening tool, a specific flaw is indicated positive if it occurs 3 times or more or has 1 extreme occurrence within 10 jumps. No extreme flaws were occurred by the testers.

The number of subjects was three in total. Two physiotherapy students assessed all three subjects and scored them based on the field screening tool booklet. A movement flaw was indicated as positive if it occurred 3 or more times. Physiotherapist 1 reported 17 different movement flaws from three subjects in total, where Physiotherapist 2 reported 12 different movement flaws from three subjects in total. Physiotherapist 1 reported 14 (82%) positive indications out of 17 movement flaws reported. Physiotherapist 2 reported 6 (50%) positive indications out of 12 movement flaws reported. In total, 16 times a positive indication of a movement flaw was reported, either from one or both testers. For four times (25%) the testers agreed and 12 times (75%) they

disagreed of positive indication of movement flaw. This is presented in the following chart below.

As the testers agreed on 4 of the 16 variables, this gives the percent agreement of two raters to be 25% of the variables where one or two raters found a flaw. The results were analyzed for percentage of exact agreement (PEA), where agreed variables are divided by the total number of variables and multiplied by 100. ((agreed/disagreed) x 100). This gives the PEA of (24/36) ×100 = 66%.

In addition, Kappa coefficient was used in analyzing to exclude guessing of the results by testers. The equation for κ is:

$$\kappa = \frac{p_o - p_e}{1 - p_e} = 1 - \frac{1 - p_o}{1 - p_e},$$

Figure 3. The formula to calculate Cohen's Kappa. Website of statisticshowto.com.

where Pr(o), is the relative observed agreement among raters, and Pr(e) is the hypothetical probability of chance agreement, calculating the probabilities of each tester to randomly saying each category. The Kappa statistics vary from 0 to 1, where 0= agreement equivalent to chance, 0,1-0,2= slight agreement, 0,21-0,4=fair agreement, 0,41-0,6=moderate agreement, 0,61-0,8=substantial agreement, 0,81-0,9=near perfect agreement and 1=perfect agreement. For the reliability of the field screening tool between two testers, the reliability based on Cohen's Kappa was 0,322, which refers to a fair agreement.

8.1 Ligament Dominance Dysfunction

Ligament Dominance Dysfunction (LiDD) consists from three flaws which are: A) knee valgus of one leg at landing; B) knee valgus both legs at landing; and C) foot placement too narrow/ at landing. In LDD, five dysfunctions were reported, three of which were disagreed and two agreed.

.

	Ligament Dominance Dysfuntion

	Test A		Test B		Test C	
	Physio 1	Physio 2	Physio 1	Physio 2	Physio 1	Physio 2
Subject 1	-	5	10	-	-	-
Subject 2	-	-	10	10	-	1
Subject 3	-	1	9	5	-	3

8.2 Quadriceps Dominance Dysfunction

Quadriceps Dominance Dysfunction (QDD) consists from three flaws which are: A) knee flexion <40° at initial contact; B) little change in knee flexion at landing; and C) flat footed/excess noise at landing. In QDD, two dysfunctions were reported, and both were disagreed, meaning only one of the tester reported findings.

	Quadriceps Dominance Dysfunction					
	Test A		Test B		Test C	
	Physio 1	Physio 2	Physio 1	Physio 2	Physio 1	Physio 2
Subject 1	-	-	-	-	-	-
Subject 2	8	-	8	-	-	-
Subject 3	-	-	-	-	-	-

8.3 Leg Dominance Dysfunction

Leg Dominance Dysfunction (LeDD)consists from three flaws which are: A) foot contact not simultaneous at initial contact; B) feet not parallel (front to back) at landing; and C) thighs not equal height/not parallel with ground at peak. In LeDD, four dysfunctions were reported, one agreed and three disagreed by the testers.

	Leg Dominance Dysfunction					
	Test A		Test B		Test C	
	Physio 1	Physio 2	Physio 1	Physio 2	Physio 1	Physio 2
Subject 1	3	-	1	-	6	4
Subject 2	-	-	-	-	8	-
Subject 3	-	1	-	-	3	1

8.4 Trunk Dominance Dysfunction

Trunk Dominance Dysfunction (TDD) consist from three flaws which are: A) excess lateral trunk movement at peak or landing; B) pause between jumps; and C) not landing in same footprint. In TDD, five dysfunctions were reported, one being agreed and four disagreed by the testers.

	Trunk Dominance Dysfunction					
	Test A		Test B		Test C	
	Physio 1	Physio 2	Physio 1	Physio 2	Physio 1	Physio 2
Subject 1	-	1	3	-	3	-
Subject 2	-	-	1	-	5	1
Subject 3	3	-	1	-	5	4

9. CONCLUSION

First research question asked if subjects have movement pattern flaws based on field screening tool. Based on the assessment of all three subjects and on all the possible movement flaws (occurred once or more), two testers together discovered 29 movement flaws in total. The field screening tool consists from 12 specific flaws for one

subject. Positive indication of a movement flaw (a flaw occurring 3 or more times during 10 tuck jumps) was discovered 16 times in total.

Second research question asked, if movement pattern flaws amongst the subjects occur, are the results reliable between two different testers. Based on the analysis of the results, it is shown that one-fourth of the findings correlated between two testers. This data consists from the positive indications reported in the assessment, not on the movement flaws which were agreed negative by both testers.

Strongest correlation in reliability was found in assessing 1) knee valgus of both legs. In this part, both testers found similar positive findings from two subjects. Based on this, it can be concluded that the strongest evidence in reliability in the use of field screening tool arises from assessing knee valgus of both legs. In addition, testers showed reliable findings in assessing 2) thigh height/not parallel with ground at peak and 3) not landing in same footprint.

Based on the kappa statistic the results indicate an agreement of 0.32, which is considered as a fair agreement. This result falls into the category of 0.21-0.4. A fair agreement in a health care study should not be considered with great confidence.

10. DISCUSSION

The topic of the thesis developed from the interest towards ACL injury and screening in general. Previous physiotherapy students modified a screening tool, which then opened a possibility for a student to investigate the topic even more. The initial plan was to use the field screening tool for anterior cruciate ligament in young women in a practical way. Testing a group of subjects was an aspect in research which was not covered during the studies, and it opened a opportunity to deepen the skills in this field.

As the thesis continued, it was decided to address the reliability of the screening tool. A natural way for the thesis was to utilize the physiotherapy students in the study process. As the topic was confirmed, the thesis process proceeded by familiarizing with the key elements of the thesis, these being ACL injury and reliability in testing in health care. In addition, exploring the field screening tool was in the center as literature around the topic was researched. At this stage the research questions were decided. Two factors of the field screening tool were under examination. Firstly, how many faulty movement patterns are discovered by two testers testing three subjects. Secondly, how much of these findings correlate with one another.

Selecting the testers and subjects participating in the thesis were decided based on the possibility for physiotherapy students to participate in a study, and to include subjects which are suitable for the screening tool. This followed with the education of the testers for the screening tool, and practical part of the thesis was proceeded in two days. After the implementation the data was collected and analyzed.

Testing the screening tools, their reliability and validity is a key element in providing evidence-based studies and practice. As the thesis process proceeded, limitations and questions occurred. Firstly, the size of the sample and testers is relatively small, ultimately affecting on the results and their significance. Secondly, the testers were not graduated physiotherapist and showed different interest within the field of physiotherapy. On the other hand, the FST presented its benefits as a low cost, accessible and fast to use screening tool. These factors allowed the process being executed by students. The benefits of FST were noticed and confirmed during the process, the booklet offered a simple, clear, evidence-based platform for the physiotherapist to use. Recording the tuck jump tests required little knowledge in technology, and the assessment tool was clear in scoring.

Such findings were expected before the testing due to subjectivity of a tester, regardless of familiarizing the testers with the screening tool. The testers showed great difference and agreement in interpreting and analyzing the video records. In addition, the testing was implemented on consecutive days, which might affect the results and how the subjects performed.

For future research, the field testing tool could be assessed for a women sports team, where a graduated physiotherapist performs the screening and proceeds by using the intervention guide based on the findings. Moreover, the validity of the field screening tool should be placed with interest in following studies.

Development of clinical assessment to identify athletes at risk of ACL injury would help physiotherapist and clinicians to target the population who would benefit the most from intervention. We have identified risk factors for ACL injury, such as high knee abduction moments during landing, but the measurement tools (motion analysis, force plates) show to be expensive. Research has been forced to develop inexpensive measurement tools to predict ACL injury. Knee abduction moment arm forces can be measured by less expensive tools. These clinical prediction tools vary in interrater reliability from moderate to high reliability. Researchers are continuing to simplify and optimize the screening tools to include a calibrated physician's scale, a standard measuring tape, standard camcorder, ImageJ software, and an isokinetic dynamometer. Creation and development of inexpensive tools to identify and eventually enroll athletes to appropriate injury prevention programs may help to reduce future ACL injuries. (Hewett et al. 2016)

REFERENCES

Alkula, T., Pöntinen, S. & Ylösatalo, P. 1995. Sosiaalitutkimuksen kvantitatiiviset menetelmät.

Augustsson, S., & Ageberg, E. 2017 Weaker lower extremity muscle strength predicts traumatic knee injury in youth female but not male athletes. http://bmjopensem.bmj.com/content/3/1/e000222#ref-7

Boden, B., Sheehan, F., Torg, J., Hewett, T. 2010. Referred 25.1.2017 Non-contact ACL Injuries: Mechanisms and Risk Factors https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3625971/

Chaudhari, AM & Andriacchi, TP. The mechanical consequences of dynamic frontal plane limb alignment for non-contact ACL injury. 2006. Referred 3.1.2018

Hegedus, E. MacDonough, S. Bleakley, C. Cook, C. Baxter, G. 2017. Clinician-friendly lower extremity physical performance measures in athletes: a systematic review of measurement properties and correlation with injury, part 1. The tests for knee function including the hop tests. https://pdfs.semanticscholar.org/370a/57d28a95521bca04b0f26d9c7165e46ec56e.pdf

Heikkilä, T. 2004. Tilastollinen tutkimus. Referred 1.1.2018.

Hewett TE, Myer GD, Ford KR, et al.2005 Biomechanical measures of neuromuscularcontrol and valgus loading of the knee predict anterior cruciate ligament injury riskin female athletes: a prospective study. Referred 22.12.2017.

Hewett, TE., Myer, GD & Ford, KR. Anterior cruciate ligament injuries in female athletes: Part 1, mechanisms and risk factors. 2006 Referred 3.1.2018

Hewett, TE., Myer, GD., Ford, KR, et al 2016. Mechanisms, prediction, and prevention of ACL Injuries: Cut risk with three sharpened and validated tools. Referred 29.1.2018.

Hirsjärvi, S. Remes, P & Sajavaara, P. 2005. Tutki ja kirjoita.

Hirsjärvi, S., Remes, P. & Sajavaara, P. 2009. Tutki ja kirjoita.

Kankkunen, P. & Vehviläinen-Julkunen, K. 2009. Tutkimus hoitotieteessä. Referred 22.12.2017

Kilem, G.L. 2014. Handbook of Inter-Rater Reliability. Referred 2.10.2017. https://books.google.fi/books?hl=fi&lr=&id=fac9BQAAQBAJ&oi=fnd&pg=PP1&dq=reliability+inter+rater&ots=UV8u9Gzp7e&sig=x9O02TyvBRaKYbFfFiZu1OBprbA&redir_esc=y#v=onepage&q&f=true

MaCall et al. 2015. Injury risk factors, screening tests and preventative strategies: a systematic review of the evidence that underpins the perceptions and practices of 44 football (soccer) teams from various premier leagues. Referred 11.10.2017. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4413799/

McHugh, ML. 2012. Interrater reliability: the kappa statistic https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3900052/

Minick, K., Kiesel, K., Burton, L., Taylor, A., Plisky, P., Butler, R. 2010. Interrater reliability of the functional movement screen. Referred 12.10.2017 https://www.ncbi.nlm.nih.gov/pubmed/20072050

Mishra, R.C. & Sandilya, Ankit. 2009 Reliability and Quality Management. Referred 25.1.2017. http://site.ebrary.com/lib/SAMK/reader.action?docID=10318675&ppg=12

Myer, G.D., Brent, J.L., Ford, K.R. and Hewett, T.E., 2011. Real-time assessment and neuromuscular training feedback techniques to prevent ACL injury in female athletes. Strength and conditioning journal, 33, 21-35.

Myer G.D, Ford K.R, Barber Foss K.D, et al. 2009. The relationship of hamstrings and quadriceps strength to anterior cruciate ligament injury in female athletes.

Phelan, C. & Wren, J. 2005. Exploring reliability in academic assessment. Types of reliability. Referred 22.1.2017. http://www.uni.edu/chfasoa/reliabilityandvalidity.htm

Pilsky, P., Raugh, M., Kaminski, T., Underwood, F. 2006. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. Referred 12.10.2017. https://www.ncbi.nlm.nih.gov/pubmed/17193868

Shelbourne, KD., Gray, T. & Haro, M. 2009. Incidence of subsequent injury to either knee within 5 years after anterior cruciate ligament reconstruction with patellar tendon autograft. Referred 5.1.2018. https://www.ncbi.nlm.nih.gov/pubmed/19109531

Stroube, B.W., Myer, G.D., Brent, J.L., Ford, K.R., Heidt Jr, R.S. and Hewett, T.E., 2013. Effects of task-specific augmented feedback on deficit modification during performance of the tuck-jump exercise. Journal of sport rehabilitation. 22, 7-18.

Theakston, K & Motto, R. 2016. Practical screening and intervention to reduce risk of ACL injury in young women. Thesis: Pori: Satakunta University of Applied Sciences. Referred 4.12.2017. http://urn.fi/URN:NBN:fi:amk-201604154439

Timothy E. Hewett, Gregory D. Myer, MS, Kevin R. Ford, MS, Robert S. Heidt, MD, Angelo J. Colosimo, MD, Scott G. McLean, Antonie J. van den Bogert, Mark V. Paterno, MS, PT, Paul Succop, 2005. http://journals.sagepub.com/doi/10.1177/0363546504269591 Referred. 11.10.2017.

Uusitalo, H. 1991. Tiede, tutkimus ja tutkielma. Johdatus tutkielman maailmaan.

Vilkka, H. 2005. Tutki ja kehitä. Referred 1.1.2018.

Vilkka, H. 2007. Tutki ja mittaa – Määrällisen tutkimuksen perusteet. Referred 7.1.2018

Walker, B. 2014. Urheiluvammat – ennaltaehkäisy, hoito, kuntoutus ja kinesioteippaus. VK-kustannus Oy. Referred 23.10.2017

Website of the Research Methodology. Referred 2.1.2018. https://research-methodology.net/research-methodology/reliability-validity-and-repeatability/research-validity/

Website of Statistics how to. http://www.statisticshowto.com/cohens-kappa-statistic/

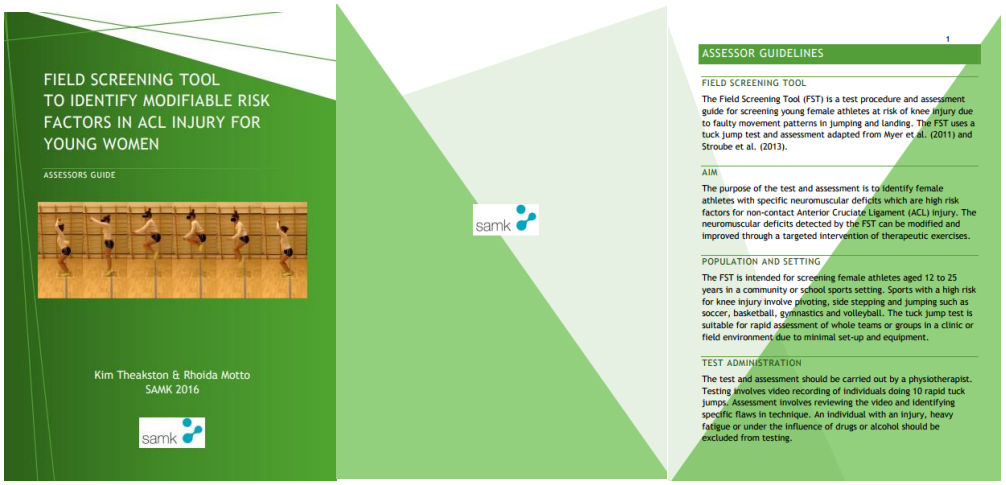
Zebis, Mette K., Andersen, Lars L., Brandt, Mikkel et al. 2015. Effects of evidence-based prevention training on neuromuscular and biomechanical risk factors for ACL injury in adolescent female athletes: a randomised controlled trial. Referred 1.1.2018 https://www.researchgate.net

APPENDIX 1

Tuck Jump Test – Field Screening Assessment Tool			
A Dysfunction is positively indicated when a Specific Flaw occurs 3 or more times OR has 1 Extreme Occurrence within the 10 jump sequence.			
Ligament Dominance Dysfunction		**Quadriceps Dominance Dysfunction**	
Knee valgus of one leg at landing		Knee flexion <40⁰ at initial contact	
Knee valgus both legs at landing		Little change in knee flexion at landing	
Foot placement too narrow/wide at landing		Flat footed / excess noise on landing	
Leg Dominance Dysfunction		**Trunk Dominance Dysfunction**	
Foot contact not simultaneous		Excess lateral trunk movement	
Feet not landing parallel (front to back)		Pause between jumps	
Thighs not equal height or not parallel at peak		Not landing in same footprint	

Assessment Notes

APPENDIX 2


FIELD SCREENING TOOL
TO IDENTIFY MODIFIABLE RISK FACTORS IN ACL INJURY FOR YOUNG WOMEN
ASSESSORS GUIDE
Kim Theakston & Rhoida Motto
SAMK 2016
samk
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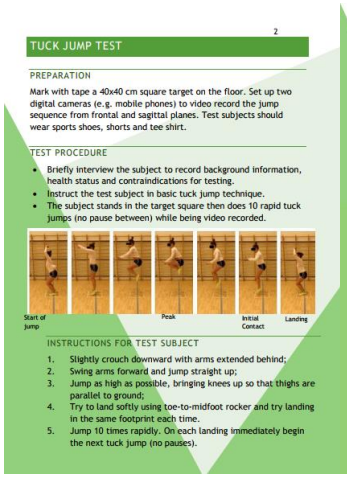
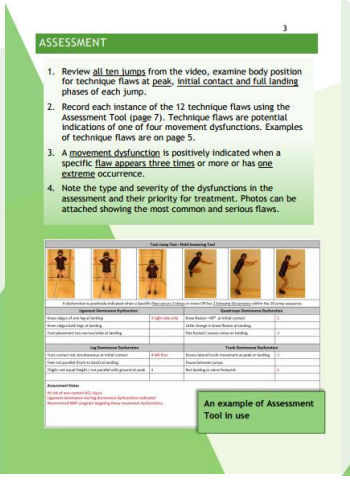
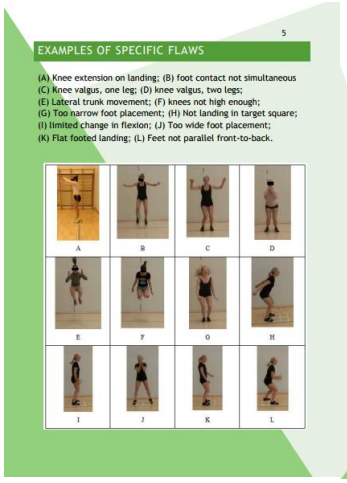
1
ASSESSOR GUIDELINES
FIELD SCREENING TOOL
The Field Screening Tool (FST) is a test procedure and assessment guide for screening young female athletes at risk of knee injury due to faulty movement patterns in jumping and landing. The FST uses a tuck jump test and assessment adapted from Myer et al. (2011) and Stroube et al. (2013).
AIM
The purpose of the test and assessment is to identify female athletes with specific neuromuscular deficits which are high risk factors for non-contact Anterior Cruciate Ligament (ACL) injury. The neuromuscular deficits detected by the FST can be modified and improved through a targeted intervention of therapeutic exercises.
POPULATION AND SETTING
The FST is intended for screening female athletes aged 12 to 25 years in a community or school sports setting. Sports with a high risk for knee injury involve pivoting, side stepping and jumping such as soccer, basketball, gymnastics and volleyball. The tuck jump test is suitable for rapid assessment of whole teams or groups in a clinic or field environment due to minimal set-up and equipment.
TEST ADMINISTRATION
The test and assessment should be carried out by a physiotherapist. Testing involves video recording of individuals doing 10 rapid tuck jumps. Assessment involves reviewing the video and identifying specific flaws in technique. An individual with an injury, heavy fatigue or under the influence of drugs or alcohol should be excluded from testing.


2
TUCK JUMP TEST
PREPARATION
Mark with tape a 40x40 cm square target on the floor. Set up two digital cameras (e.g. mobile phones) to video record the jump sequence from frontal and sagittal planes. Test subjects should wear sports shoes, shorts and tee shirt.
TEST PROCEDURE
Briefly interview the subject to record background information, health status and contraindications for testing.
Instruct the test subject in basic tuck jump technique.
The subject stands in the target square then does 10 rapid tuck jumps (no pause between) while being video recorded.
Start of Jump
Peak
Initial Contact
Landing
INSTRUCTIONS FOR TEST SUBJECT
1. Slightly crouch downward with arms extended behind;
2. Swing arms forward and jump straight up;
3. Jump as high as possible, bringing knees up so that thighs are parallel to ground;
4. Try to land softly using toe-to-midfoot rocker and try landing in the same footprint each time.
5. Jump 10 times rapidly. On each landing immediately begin the next tuck jump (no pauses).


3
ASSESSMENT
1. Review all ten jumps from the video, examine body position for technique flaws at peak, initial contact and full landing phases of each jump.
2. Record each instance of the 12 technique flaws using the Assessment Tool (page 7). Technique flaws are potential indications of one of four movement dysfunctions. Examples of technique flaws are on page 5.
3. A movement dysfunction is positively indicated when a specific flaw appears three times or more or has one extreme occurrence.
4. Note the type and severity of the dysfunctions in the assessment and their priority for treatment. Photos can be attached showing the most common and serious flaws.
An example of Assessment Tool in use

4
RESULTS
The result of the assessment is a positive indication in one or more of the four neuromuscular dysfunctions. These represent deficits in neuromuscular control, proprioception and strength which contribute to risk of ACL injury. Each dysfunction identified by the FST can be treated with a targeted therapeutic exercise program.
FOUR DYSFUNCTIONS
LIGAMENT DOMINANCE
A dysfunction due to lack of control of lower limbs in the frontal plane during dynamic loading, typically characterized by knee valgus at landing.
TRUNK DOMINANCE
A dysfunction due to a deficit in coordination and control of the core and hip stabilizers during dynamic movement, typically characterized by excessive lateral displacement of the trunk.
QUADRICEPS DOMINANCE
A dysfunction due to excessive muscle activation and strength of knee extensors compared to knee flexors, typically characterized by minimal knee flexion at initial contact or limited change in knee flexion during landing.
LEG DOMINANCE
A dysfunction due to an asymmetry of strength and control between legs, typically characterized by landing first with the preferred leg.


5
EXAMPLES OF SPECIFIC FLAWS
(A) Knee extension on landing; (B) foot contact not simultaneous
(C) Knee valgus, one leg; (D) knee valgus, two legs;
(E) Lateral trunk movement; (F) knees not high enough;
(G) Too narrow foot placement; (H) Not landing in target square;
(I) limited change in flexion; (J) Too wide foot placement;
(K) Flat footed landing; (L) Feet not parallel front-to-back.
A
B
C
D
E
F
G
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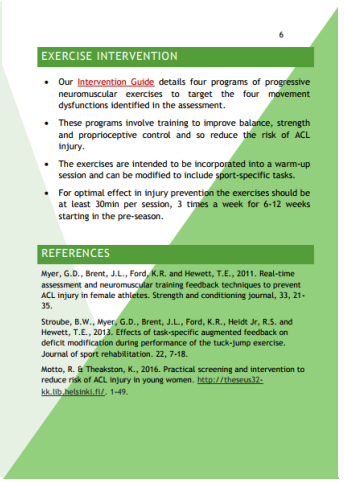
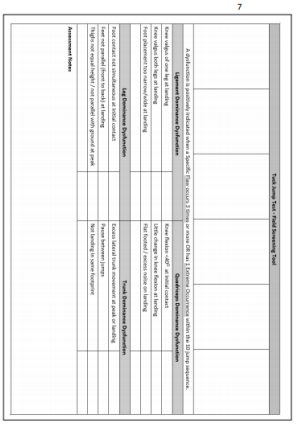

6
EXERCISE INTERVENTION
Our Intervention Guide details four programs of progressive neuromuscular exercises to target the four movement dysfunctions identified in the assessment.
These programs involve training to improve balance, strength and proprioceptive control and so reduce the risk of ACL injury.
The exercises are intended to be incorporated into a warm-up session and can be modified to include sport-specific tasks.
For optimal effect in injury prevention the exercises should be at least 30min per session, 3 times a week for 6-12 weeks starting in the pre-season.
REFERENCES
Myer, G.D., Brent, J.L., Ford, K.R. and Hewett, T.E., 2011. Real-time assessment and neuromuscular training feedback techniques to prevent ACL injury in female athletes. Strength and conditioning journal, 33, 21-35.
Stroube, B.W., Myer, G.D., Brent, J.L., Ford, K.R., Heidt Jr, R.S. and Hewett, T.E., 2013. Effects of task-specific augmented feedback on deficit modification during performance of the tuck-jump exercise. Journal of sport rehabilitation. 22, 7-18.
Motto, R. & Theakston, K., 2016. Practical screening and intervention to reduce risk of ACL injury in young women. http://theseus32-kk.lib.helsinki.fi/. 1-49.


7
Assessment Notes
Thighs not equal height / not parallel with ground at peak
Feet contact not simultaneous at initial contact
Feet not parallel front to back at landing
Not landing in same footprint
Leg Dominance Dysfunction
Knee valgus both legs at landing
Knee valgus one leg at landing
Foot placement too narrow/wide at landing
Ligament Dominance Dysfunction
Knee flexion <60° at initial contact
Little change in knee flexion at landing
Hip (trunk) L moves more on landing
Quadriceps Dominance Dysfunction
Excess lateral trunk movement at peak or landing
Trunk Dominance Dysfunction
Track Jump Test - Field Screening Tool

NOTES

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