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Study protocol for a prospective cohort study identifying risk factors for sport injury in adolescent female football players: the Karolinska football Injury Cohort (KIC)

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Manuscripts

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3 **Study protocol for a prospective cohort study identifying risk factors for**
4 **sport injury in adolescent female football players: the Karolinska football**
5
6 **Injury Cohort (KIC)**
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10

11 **Word count: 3484**
12
13

14 15 16 17 **ABSTRACT**

18 **Introduction** Football is a popular sport among young females worldwide, but studies on
19 injuries in female players are scarce compared with male players. The aim of this study is to
20 identify risk factors for injury in adolescent female football players.
21
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23

24
25 **Methods and analysis** The Karolinska football Injury Cohort (KIC) is an ongoing
26 longitudinal study that will include approximately 400 female football academy players 13-19
27 years old in Sweden. A detailed questionnaire regarding demographics, health status, lifestyle,
28 stress, socioeconomic and psychosocial factors, and various football-related factors are
29 completed at baseline and after one year. Clinical tests measuring strength, mobility,
30 neuromuscular control of the lower extremity, trunk, and neck are carried out at baseline.
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Players are followed prospectively with weekly e-mails regarding exposure to football and
other physical activity, health issues (such as stress, recovery, etc.), pain, performance, and
injuries via the Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-
O). Players who report a substantial injury in the OSTRC-O, i.e., not being able to participate
in football activities, or have reduced their training volume or performance to a moderate or
major degree, are contacted for full injury documentation. In addition to player data, academy
coaches also complete a baseline questionnaire regarding coach experience and education.

Ethics and dissemination The study was approved by the Regional Ethical Review Authority
at Karolinska Institutet, Stockholm, Sweden (2016/1251-31/4). All participating players and

1
2
3 their legal guardians give their written informed consent. The study will be reported in
4
5 accordance with the Strengthening the Reporting of Observational studies in Epidemiology
6
7 (STROBE). The results will be published in peer-reviewed academic journals and
8
9
10 disseminated to the Swedish football movement through stakeholders and media.
11

12 **Keywords:** Acute injuries, bio-psychosocial factors, girls, gradual onset injuries, soccer,
13 youth.
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ARTICLE SUMMARY

Strengths and limitations of this study

- The study will increase the knowledge about risk factors, injuries, and health issues from different bio-psychosocial domains in young female football players.
- These results may be different from results in studies regarding male players and players in other age groups and can be a ground for specific injury prevention strategies.
- We aim to have a large sample size and to collect robust data of exposures, potential confounding factors and effect measure modifiers and the study design is previously used in a similar study KHAAS, from our research group.
- Weekly self-reported data collection in adolescents might lead to misclassification of exposure and outcome.
- Using e-mails and SMS for weekly reports might decrease the response rates and thereby increase the risk of selection bias in the results.

INTRODUCTION

Four million females worldwide are registered football players, whereof 2.5 million are under 17 years old according to Fédération Internationale de Football Association (FIFA)¹. Studies regarding injuries in female football are scarce compared to the number of studies in male football players²⁻⁴. In brief, these studies show that common injuries in female football players are joint and ligament injuries to the knee and ankle joints and muscle and tendon injuries of the thigh. In addition, there is a particular concern for concussions and anterior cruciate ligament (ACL) injuries in female players^{3 5-8}.

Female football players have more absence days from football due to injuries compared to male players⁸, and long-term consequences of injuries might be considerable for young

1
2
3 football players⁹. For players with a history of injury, the risk of osteoarthritis in lower
4
5 extremity joints are high and greater than in the general population^{10 11}. Injuries may also lead
6
7 to premature career ending¹², and mental health problems¹³. Identifying risk factors for injury
8
9 is, therefore, an important step towards reduction of injury risk¹⁴. To identify possible risk
10
11 factors well-designed prospective cohort studies are needed^{15 16}, and the suggested risk factors
12
13 in this setting can be classified as bio-psychosocial factors (see Wiese-Bjornstal for bio-
14
15 psychosocial view on a sport injury risk profile)¹⁷. Biological risk factors for injury in female
16
17 players are previous injury^{7 18-20}, a hamstring/quadriceps ratio of less than 55 %, increased
18
19 body mass index (BMI), as well as results of plyometric tests e.g., poor performance in drop
20
21 jump landing test is associated with increased risk of ankle injury²¹. Other biological risk
22
23 factors are young age^{6 18}, physical complaints at the beginning of the season, familiar
24
25 disposition, i.e., a parent, sibling¹⁸, or a twin²² with knee injury also lower level of preseason
26
27 aerobic fitness is associated with an increased risk of injuries during the season^{23 24}. Results
28
29 regarding joint hypermobility in female players as a risk factor are inconclusive in older
30
31 studies^{23 25}, although in more recent published studies no relation was shown^{26 27}. Risk factors
32
33 for back pain in adolescents include rapid growth rate, and tight muscle imbalance²⁸, but risk
34
35 factors for football related back/neck injuries in young females are not known. Psychological
36
37 risk factors reported includes somatic trait anxiety, mistrust, and ineffective coping²⁹, life
38
39 event stress³⁰, and perceived mastery climate²⁰. Social factors that influenced the risk for
40
41 injuries in female athletes are coaches' and player's education regarding injury prevention
42
43 strategies³¹, stress from teammates and coaches^{20 29 32}, and for back pain in adolescents;
44
45 smoking²⁸. In football, an identified situational specific risk factor is the playing positions
46
47 defender and strikers¹⁹.
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57 In summary, there are inconsistent knowledge about risk factors for injuries in adolescent
58
59 female football players, and lack of using a bio-psychosocial perspective in research. Hence,
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1
2
3 the overall aim of the Karolinska football Injury Cohort study (KIC) is to identify risk factors
4 for injuries in adolescent female football players from a bio-psychosocial perspective.

5
6 Specific aims are to determine the incidence of injuries in young female football players and
7
8 to identify modifiable risk factors for such injuries. Secondary aims include to describe
9
10 changes in muscle strength and range of motion over a year, trajectories of pain, and to
11
12 identify important factors for not being injured over a year.
13
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16 17 18 19 **METHODS AND ANALYSIS**

20
21 This is a prospective observational cohort study designed in agreement with Strengthening the
22
23 Reporting of Observational studies in Epidemiology (STROBE) guidelines³³.

24 25 26 **Study setting and participants**

27
28
29 Football clubs with adolescent female academy players aged 12 to 19 years, participating in
30
31 Swedish divisions 1-2 for girls in the largest regions, are eligible to participate in the study.

32
33 Clubs which meet the inclusion criteria are contacted and invited to the study and given oral
34
35 and written information. Clubs which choose to take part in the study are provided with a
36
37 more detailed oral and written information in the presence of players, legal guardians, and
38
39 coaches.
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43
44 A cohort of approximately 400 adolescent academy players will be recruited. An internal pilot
45
46 study of 63 football players has been conducted to test the infra-structure and the
47
48 implementation of the study, with satisfactory results (unpublished data).
49
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51 52 **Baseline measurements**

53 54 **Questionnaires**

55
56
57 The baseline questionnaire covers potential risk factors for the aetiology of sport injuries as
58
59 well as information about players' general health status. Players are surveyed in various areas
60

1
2
3 including a) *health*: health problems (e.g. illness), medication, age at menarche, amenorrhea,
4
5 b) *lifestyle*: sleep patterns, eating habits, food supplements, tobacco as smoking or Swedish
6
7 snus (snuff) and alcohol, c) *socioeconomic* factors: guardians' education, d) *football-related*
8
9 *factors*: training and match play exposure, playing position, dominant limb, years of
10
11 experience, other sports participation, injury preventive strategies (e.g. the Swedish injury
12
13 prevention warm-up programme Knee Control)³⁴ (33), type of turf at the home facilities
14
15 (artificial or natural grass) according to guidelines for football studies³⁵⁻³⁷, e) *psychosocial*
16
17 *factors*: modified General Health Questionnaire-12 (GHQ-12) consisting of 12 items
18
19 regarding self-reported general psychological health using a four-point Likert scale³⁸, coping
20
21 assessed by a 28 item self-report questionnaire that measure effective and ineffective
22
23 strategies to cope with stressful events using a four-point Likert scale (Brief COPE)³⁹,
24
25 player's passion to sport measured in harmonious and obsessive passions using a 14 item
26
27 questionnaire with a seven-point Likert scale (Passion scale)⁴⁰, education in sport psychology,
28
29 regularly seeing a sport psychologist/mental coach and perceived stress (single item
30
31 question)⁴¹, f) *previous injury history*: injuries occurring two- and three to six months prior to
32
33 inclusion are captured using a modified Swedish version of the validated psychometric
34
35 instrument Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O)⁴²
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In addition, coaches in the included teams are surveyed regarding their education, years of experience, the use of warm-up and stretching regime and implementation of injury prevention programmes.

Physical test protocol

1
2
3 The physical test protocol includes several tests that are considered valid, reliable, and field
4 friendly; performed in approximately 60 minutes/player. The protocol comprises
5
6 measurements of strength, mobility and control of lower extremity, trunk and neck and also
7
8 include anthropometric measurements (height, weight and leg length) and are described
9
10 briefly below and in more detail with visual presentations in the electronic supplementary file
11
12 (Supplement 1).
13
14
15

16
17 All test procedures are conducted in indoors facilities during weekends. The physical tests are
18
19 divided into nine test stations with 1-2 test leaders each (Supplement 1). Throughout the
20
21 study, the total number of test leaders/pairs of test leaders who has performed each station
22
23 ranges from 3-9. Hitherto, 52 clinically experienced test leaders have been involved in data
24
25 collection. They were trained by MA, VL, NW and the previous test leader in charge of the
26
27 station to ensure consistent execution and reliability. Information and instructions given to the
28
29 players regarding the tests are standardized and test leaders refrain from coaching or
30
31 encouraging the players in any way during the procedures.
32
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35

36
37 A maximum of nine players are tested per session (i.e. one at each station) and are informed
38
39 to train and compete as usual prior to testing. Players are informed to refrain from certain tests
40
41 that evoke pain, provoke ongoing injuries or other health-related issues. Prior to performing
42
43 the physical tests, players complete a standardized seven-minute warm-up programme
44
45 comprising four minutes of jogging, 10 x 1 body weight squats, 10 x 1 body weight squat
46
47 jumps, and 10 x 1 unilateral body weight lunges. Following the warm-up session, players are
48
49 randomly assigned to a starting test station and subsequently follow a predefined order.
50
51
52

53 *Calf heel raises*

54
55
56 Ankle plantarflexion (PF) muscle endurance is investigated using unilateral weight bearing
57
58 calf heel raises⁴⁶. The player is instructed to perform maximum unilateral barefoot heel raises
59
60

1
2
3 continuously to failure, guided by a metronome to standardize the pace (1 second concentric-,
4
5 1 second eccentric contraction). The test leader registers the number of accomplished
6
7 repetitions and discontinues when the player fails to reach the marked target height. The same
8
9 procedure is then conducted on the opposite foot.
10
11

12 *Active plantarflexion mobility*

13
14
15 Active PF range of motion (ROM) is measured with a universal goniometer in supine position
16
17 utilizing fibula and fifth metatarsal as reference marks^{47 48}. The player is instructed to
18
19 maintain extended knees throughout the movement, and to perform a sequence of six maximal
20
21 active PF cycles from a neutral dorsiflexion (DF) position, whereof the finishing three trials
22
23 are registered.
24
25

26 *Weight bearing ankle dorsiflexion mobility*

27
28
29 Weight bearing ankle DF ROM is measured in a lunge position with the player's foot placed
30
31 upon a metric ruler 10 cm away from a wall^{46 49}. The player is instructed to lunge forward,
32
33 until contact with the wall is achieved without allowing the heel to lift off the ground. Three
34
35 warm-up trials are performed from the 10 cm mark to familiarize the player with the test.
36
37 Thereafter, the test leader measures the following three trials. From the 10 cm reference mark,
38
39 the player progresses 1 cm away at a time from the wall until unable to perform a successful
40
41 repetition. If unable to perform a successful repetition at the 10 cm reference mark, she is
42
43 asked to progress 1 cm forward until able to complete a successful repetition. The maximal
44
45 DF ROM is measured with a digital inclinometer (Clinometer, Plaincode, Stephanskirchen,
46
47 Germany) and distance from the wall to the greater toe is measured in cm.
48
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51

52 *Trunk mobility*

53
54
55 Trunk rotation mobility is measured in a modified seated rotation test, and a in a lunge
56
57 position on a gym mat graded with 5 degrees increments⁵⁰⁻⁵². The player is instructed to
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3 maximally rotate alternating between right and left, in a cross-legged position and
4
5 subsequently in a lunge position on the dominant, and non-dominant limb whilst the test
6
7 leader measures the rotational degrees in the end range. Three repetitions are performed in
8
9 each direction during the three separate positions, and the mean value for each position is later
10
11 used for analysis.
12
13

14 15 *Trunk strength*

16
17 Isometric trunk rotational strength is measured in a modified standing wood chopper test
18
19 utilizing a force gauge to evaluate force output (RS Pro Digital Force Gauge, RS Components
20
21 Ltd., Corby, UK)⁵³⁻⁵⁵. In this modified test, the player holds a handle attached to the force
22
23 gauge in shoulder height in a standing position. The player is instructed to generate force
24
25 through her trunk and rotate for five seconds whilst maintaining straight arms. Three
26
27 consecutive repetitions are conducted in each direction and the maximal force output is later
28
29 used for analysis.
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33 34 *Deep neck flexor endurance*

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36
37 Deep neck flexor muscle endurance is assessed through a modified version of the Cranio-
38
39 cervical flexion test (CCFT) with a pressure sensor (Stabilizer Pressure Bio-Feedback,
40
41 Chattanooga Group Inc, Hixon, TN)^{51 56 57}. The test consists of a pre-test and an endurance
42
43 test. In the pre-test the player is positioned in a supine position on an examination table and
44
45 are instructed to slightly push the neck against the pressure sensor to increase the pressure and
46
47 then maintain the pressure for 3 × 3 seconds, with a 3 second rest in between each contraction,
48
49 at a specific target pressure (TP), starting at 20 mmHg. If the player can perform this task, she
50
51 is instructed to increase the pressure to 24 mmHg and keep the pressure for another 3 × 3
52
53 seconds. This is repeated with a 2-mmHg increase until the player reaches 30 mmHg. If the
54
55 player can perform the pre-test the endurance test is subsequently performed. During the
56
57 endurance test, the same setup and procedure as in the pre-test is carried out. However, the
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3 player is instructed to hold each contraction at the TP for 3 x 10 with a 10 second rest in
4
5 between contractions. The highest completed TP with a full set of 3 x 10 seconds contractions
6
7 is later used for analysis.
8
9

10 *Hip and knee strength*

11
12 Isometric hip flexion, extension, adduction and abduction strength as well as eccentric hip
13
14 abduction and adduction strength are measured with a hand-held dynamometer (HHD)
15
16 (MicroFet2, Hoggan Health Industries inc. West Jordan, UT, USA)^{58 59}. Furthermore,
17
18 isometric knee extension strength is measured with a HHD and the player in a seated position
19
20 with the knee joint in 90-degrees of flexion. Prior to executing the strength tests, two
21
22 submaximal isometric contractions in each direction are performed to familiarize the player
23
24 with the procedures. Three isometric contractions with gradually increasing power output for
25
26 five seconds, and three maximally eccentric contractions for three seconds are performed in
27
28 the isometric and eccentric tests, respectively, with a 10 second rest in between contractions.
29
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33
34 The maximal power output for each position is later used for analysis.
35

36 *Hip mobility*

37
38 Measures of passive hip ROM in flexion and abduction in prone position and extension,
39
40 internal- and external rotation in supine position is obtained using a universal goniometer^{60 61}.
41
42
43 Three consecutive measurements for each position are performed for both the dominant and
44
45 the non-dominant leg, and the mean value for each position is later used for analysis.
46
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49 *Functional performance tests*

50
51 To assess the player's unilateral jump performance, the One-leg Long Box Jump Test
52
53 (OLLBJ) and square hop test are performed^{62 63}. A 40 x 40 cm square is marked on the
54
55 foundation and later utilized as a reference mark in both tests.
56
57

58
59 In the OLLBJ, the starting position are calculated by dividing the player's height (cm) with
60

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3 1.6 (height / 1.6). Thereafter, the player is instructed to stand on one leg on the starting
4
5 position and then jump on one leg directed inside the boundaries of the square and maintain
6
7 balance after landing. Three warm up trials and five consecutive test trials are performed on
8
9 each leg. The total number of approved trials are registered by the test leader.
10
11

12 During the square hop test, previously described in detail^{62 63}, the player is instructed to jump
13
14 on one leg in and out of the square as many times as possible for 15 seconds in a clockwise
15
16 direction, timed with a stopwatch whilst the test leader registers the number of approved
17
18 jumps. The player performs two warm up trials on each foot prior to executing the test.
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22 *Ankle and knee stability*

23
24 To assess stability of player's talocrural joints, a modified anterior drawer test is employed⁶⁴
25
26 ⁶⁵. Furthermore, a modified version of Fairbank's apprehension test is utilized to evaluate the
27
28 player's stability in the patellofemoral joint⁶⁶. The tests are conducted on both the dominant
29
30 and non-dominant foot and knee and are considered positive if the player experience any pain
31
32 or discomfort during the examination, and/or an involuntary contraction of the quadriceps
33
34 musculature occur during the Fairbank's apprehension test.
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39 *Isometric back extensor endurance*

40
41 Isometric back extensor endurance is assessed by the modified Sorensen test⁶⁷⁻⁶⁹. In this
42
43 previously described modified test^{67 68}, the player's lower body are supported to an
44
45 examination table in prone position with three straps and the anterior-superior iliac spine is
46
47 aligned with the edge of the table. The player is instructed to keep her arms folded across the
48
49 chest throughout the procedure and isometric maintaining the upper body in a horizontal
50
51 position until failure whilst the test leader register the time elapsed. A digital inclinometer
52
53 (Clinometer, Plaincode, Stephanskirchen, Germany) is placed upon a metric ruler at the level
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55 of th5 in the thoracic spine to monitor sagittal plane movement. Prior to the assessment, the
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3 player completes a shorter warmup trial to orient the desired sagittal plane target angle.
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6 **Follow-up measurement and outcome** 7

8
9 Follow-up measurements are collected prospectively during one year from the baseline. In the
10 weekly online questionnaire, the players are asked to answer questions regarding new and
11 ongoing injuries, LBP and UBNP intensity, social support, perceived stress, recovery, and to
12 be able to consider workload, number of training and match play hours/week⁷⁰. To assess
13 whether players sustain football related injuries throughout the follow-up period, the Swedish
14 version of OSTRC-O is employed and included in the weekly online questionnaire^{42 43 71}. The
15 OSTRC-O was modified by adding a question regarding absence/reduced participation in
16 training/match due to reasons not related to injuries were added, as well as the option to
17 specify injuries in different anatomical localizations in the lower- and upper extremity, back,
18 neck, head and abdomen.
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33 Football related injuries reported with the OSTRC-O in the weekly online questionnaire
34 leading to moderate or severe reductions in participation/and or sports performance or
35 complete inability to participate in sport are classified as a substantial injury in this study⁴².
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38 Players reporting new substantial injuries are contacted on telephone by a clinically
39 experienced research assistant to answer a standardized interview with questions concerning
40 the injury such as: injury mechanism, localisation, type, time-loss, re-injury, diagnosis, and
41 medical care. Injuries are divided into acute and gradual onset. An acute injury is defined as a
42 result from a specific, identifiable event, whereas injuries with gradual onset are defined as an
43 injury without a single, identifiable event responsible for the injury³⁵. Players receive an
44 automated link to the online questionnaire sent by email each Sunday, with a reminder email
45 the next day to players not answering. Furthermore, if no response is received, a text message
46 reminder with the link is sent on Tuesdays. Finally, every other week representatives of the
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study visits football clubs with players active in the study to collect unanswered surveys for the previous two-week period.

After 52 weeks of participation, a questionnaire with equivalent content as the baseline questionnaire (excluding OSTRC-O with 2- and 3-6-month recall) are distributed to the players to evaluate possible changes from the baseline characteristics. The first 106 included players also underwent a secondary physical test protocol after 52 weeks of follow-up. In the one-year follow-up questionnaire, different aspects of UBP and LBP, respectively, in the preceding six months are measured. “Have you had UBP/Have you had LBP” (Yes/No)? If yes, has the pain hindered your daily activities (No, Yes to some extent or Yes to a high degree)? If Yes, the “Visual Trajectories Questionnaire – Pain” is used to capture the longitudinal state of a player's pain experience of UBP and LBP and are retrospectively reported for the preceding six-month period⁴⁵. See Table 1 for an overview of the measurements during the different phases of the study.

Table 1. Summary of the included measurements during the different phases of the study.

Phase	Measurements	Tests/tools
Baseline: players (consecutive during inclusion; 2016-ongoing)	Demographic information, general health status (history of pain, illness, medication, plagues, menstrual cycle, back and neck pain), lifestyle (sleep patterns, resilience, food supplements, use of tobacco or alcohol), stress, socioeconomic factors (guardians' education), football related factors (position, years of experience, injury preventive strategies).	KIC Baseline players, The Chronic Pain Questionnaire (CPQ) ⁴⁴ , Visual Trajectories Questionnaire-Pain (VTQ-P) ⁴⁵ ,
	Anthropometric measurements (height, weight,	KIC test protocol

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leg length), and measurement of strength, mobility and control of lower extremity, trunk, and neck.

History of injury and complaints Modified
OSTRC-O^{42 43}
Passion Passion scale⁴⁰
General Health GHQ-12³⁸
Coping strategies Brief COPE³⁹

Baseline: coaches Education, years of experience, the use of KIC Baseline
(consecutive during warm-up and stretching regime and coaches
inclusion; 2016- implementation of injury prevention programs.
ongoing)

Weekly follow-up: Exposure to football training and match play KIC weekly
players (September report
2016-ongoing)

Exposure to other physical activity.
Health (e.g. stress, recovery) and social support.
Report on pain, injury performance complaints. Modified
OSTRC-O^{42 43}

In case of a Report on injury/complaint (type of injury, KIC medical
substantial injury localisation, inciting event) report
event

One-year follow-up: Football related factors (position, injury KIC One-year
players (consecutive preventive strategies) questionnaire
after 52 weeks Health status (pain in back or neck) lifestyle
participation: 2017- (sleep patterns, resilience, food supplements,
ongoing) use of tobacco or alcohol, physical activity),
stress, coping and passion for sport.

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3 One-year follow-up Anthropometric measurements (height, weight, KIC test protocol
4 (consecutive after 52 leg length), and measurement of strength,
5 weeks participation mobility and control of lower extremity, trunk,
6 in the first 106 and neck.
7 included players)
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12 13 14 15 **Sample size**

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18 The statistical power for the analyses will depend on the exact research question, the number
19 of exposed players and on if the exposure is continuous or categorized. The sample size in the
20 KIC-project is based on the definition “a substantial injury” as proposed by Clarsen et al.,⁴²,
21 and back injuries in adolescent female players in a previously published study⁷. Based on a
22 relative risk of 1.9 for a substantial injury in the back/neck, when 88 of the players are
23 exposed, and with a power of 0.80, a significance level 5 % and with potential 10% drop out
24 and a follow-up time of one year to identify risk factors, 420 players will be included.
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35 **Statistical methods**

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37 The data in the KIC study will be used to answer several different research questions and
38 accordingly different analyses methods and statistics will be used. Primary, Kaplan-Meier
39 estimates will be used to describe incidence, and Cox regression analyses or discrete time
40 survival analyses to measure the associations between exposure and outcome, and to adjust
41 for confounding . Only players without substantial injuries the two preceding months
42 (reported in the baseline questionnaire) will be considered in the risk analyses, and stratified
43 analyses to examine effect measure modification will be performed when relevant. The
44 development of injuries is likely complex and that is why we measure an extensive number of
45 factors so that we can consider confounders, intermediators, and effect measure modifier in
46 these analyses. When identifying trajectories of time varying factors Generalized Estimating
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3 Equations will be used for these analyses to consider the covariance between repeated
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5 measurements.
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8 9 **Time plan**

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12 Approximate 400 players will be recruited from 2017 and followed weakly for one year from
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14 inclusion regarding injuries/complaints. Players will consecutively be invited and included
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16 from the year as the turn 13 years old and play in a participating club.
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19 20 **Data statement**

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23 The dataset and statistical codes will be available when the data collection is completed.
24
25

26 27 **Patient and public involvement**

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30 No patient involved
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35 36 **ETHICS AND DISSEMINATION**

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38 The study was approved by the Regional Ethical Review Authority at Karolinska Institutet,
39
40 Stockholm, Sweden (2016/1251-31/4). All participating players and their legal guardians
41
42 receive written and oral information regarding the study and give their written informed
43
44 consent when entering the study. Players under the age of 15 are required to have written
45
46 informed consent from their legal guardians. The study will be performed in accordance with
47
48 the recommendations guiding research involving human subjects adopted by the 18th World
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50 Medical Association General Assembly, Helsinki, Finland, June 1964, amended at the 64th
51
52 World Medical Association General Assembly, Fortaleza, Brazil, October 2013. The study
53
54 will be reported in accordance with the Strengthening the Reporting of Observational studies
55
56 in Epidemiology (STROBE)³³. The results will be presented in scientific conferences and
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3 published in peer-reviewed academic journals as well as being disseminated to the Swedish
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5 football movement through stakeholders and media.
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FOOTNOTES

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Author Contributions VL, ES, MA and UT initiated the study. All authors conceived the study and contributed to the development of the study protocol. ES is the study guarantor and submitted to ethic committee. UT and NW drafted the manuscript which was critically revised by all co-authors. The final manuscript was approved by all authors.

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REFERENCES

1. Federation Internationale de Football Association F. Women's football survey. 2014. (accessed 2020-11-03).
2. López-Valenciano A, Ruiz-Pérez I, Garcia-Gómez A, et al. Epidemiology of injuries in professional football: a systematic review and meta-analysis. *Br J Sports Med* 2020;54(12):711-18. doi: 10.1136/bjsports-2018-099577 [published Online First: 2019/06/07]
3. Bennett P, Fawcett L. Trauma injuries sustained by female footballers. *Trauma* 2006;8(2):69-76. doi: 10.1177/1460408606072682
4. Hägglund M, Waldén M, Ekstrand J. Injuries among male and female elite football players. *Scand J Med Sci Sports* 2009;19(6):819-27.
5. Faude O, Junge A, Kindermann W, et al. Injuries in female soccer players - A prospective study in the German national league. *Am J Sport Med* 2005;33(11):1694-700. doi: 10.1177/0363546505275011
6. Le Gall F, Carling C, Reilly T. Injuries in young elite female soccer players. *Am J Sport Med* 2008;36(2):276-84. doi: 10.1177/0363546507307866
7. Clausen MB, Zebis MK, Moller M, et al. High Injury Incidence in Adolescent Female Soccer. *Am J Sport Med* 2014;42(10):2487-94. doi: 10.1177/0363546514541224
8. Larruskain J, Lekue JA, Diaz N, et al. A comparison of injuries in elite male and female football players: A five-season prospective study. *Scand J Med Sci Sports* 2018;28(1):237-45. doi: 10.1111/sms.12860
9. Lohmander LS, Ostenberg A, Englund M, et al. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum* 2004;50(10):3145-52. doi: 10.1002/art.20589
10. Prien A, Prinz B, Dvorak J, et al. Health problems in former elite female football players: Prevalence and risk factors. *Scand J Med Sci Sports* 2017;27(11):1404-10. doi: 10.1111/sms.12747
11. Roos EM. Joint injury causes knee osteoarthritis in young adults. *Curr Opin Rheumatol* 2005;17(2):195-200.
12. Wylleman P, Reints A. A lifespan perspective on the career of talented and elite athletes: Perspectives on high-intensity sports. *Scand J Med Sci Sports* 2010;20:88-94. doi: 10.1111/j.1600-0838.2010.01194.x
13. Putukian M. The psychological response to injury in student athletes: a narrative review with a focus on mental health. *Brit J Sport Med* 2016;50(3):145-48. doi: 10.1136/bjsports-2015-095586
14. Van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. *Sports Med* 1992;14(2):82-99.
15. Dvorak J, Junge A, Chomiak J, et al. Risk factor analysis for injuries in football players - Possibilities for a prevention program. *Am J Sport Med* 2000;28(5):S69-S74.
16. Steffen K, Engebretsen L. More data needed on injury risk among young elite athletes. *Brit J Sport Med* 2010;44(7):485-89. doi: 10.1136/bjism.2010.073833
17. Wiese-Bjornstal DM. Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a consensus statement. *Scand J Med Sci Sports* 2010;20(s2):103-11. doi: 10.1111/j.1600-0838.2010.01195.x
18. Hägglund M, Waldén M. Risk factors for acute knee injury in female youth football. *Knee Surg Sport Tr A* 2016;24(3):737-46. doi: 10.1007/s00167-015-3922-z
19. Faude O, Junge A, Kindermann W, et al. Risk factors for injuries in elite female soccer players. *Brit J Sport Med* 2006;40(9):785-90. doi: 10.1136/bjism.2006.027540

20. Steffen K, Pensgaard AM, Bahr R. Self-reported psychological characteristics as risk factors for injuries in female youth football. *Scand J Med Sci Sports* 2009;19(3):442-51. doi: 10.1111/j.1600-0838.2008.00797.x
21. Alahmad TA, Kearney P, Cahalan R. Injury in elite women's soccer: a systematic review. *Phys Sportsmed* 2020;1-7. doi: 10.1080/00913847.2020.1720548 [published Online First: 2020/02/07]
22. Magnusson K, Turkiewicz A, Hughes V, et al. High genetic contribution to anterior cruciate ligament rupture: Heritability ~69%. *Br J Sports Med* 2020;55(7):385-89. doi: 10.1136/bjsports-2020-102392
23. Ostenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123 players during one season. *Scand J Med Sci Sports* 2000;10(5):279-85. doi: 10.1034/j.1600-0838.2000.010005279.x
24. Watson A, Brickson S, Brooks MA, et al. Preseason aerobic fitness predicts in-season injury and illness in female youth athletes. *Orthop J Sports Med* 2017;5(9) doi: 10.1177/2325967117726976
25. Soderman K, Alfredson H, Pietila T, et al. Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surg Sport Tr A* 2001;9(5):313-21. doi: 10.1007/s001670100228
26. Nilstad A, Andersen TE, Bahr R, et al. Risk factors for lower extremity injuries in elite female soccer players. *Am J Sport Med* 2014;42(4):940-48. doi: 10.1177/0363546513518741
27. Blokland D, Thijs KM, Backx FJ, et al. No effect of generalized joint hypermobility on injury risk in elite female soccer players: A prospective cohort study. *Am J Sports Med* 2017;45(2):286-93. doi: 10.1177/0363546516676051
28. Feldman DE, Shrier I, Rossignol M, et al. Risk factors for the development of neck and upper limb pain in adolescents. *Spine* 2002;27(5):523-28.
29. Johnson U, Ivarsson A. Psychological predictors of sport injuries among junior soccer players. *Scand J Med Sci Sports* 2011;21(1):129-36. doi: 10.1111/j.1600-0838.2009.01057.x
30. Ivarsson A, Johnson U, Lindwall M, et al. Psychosocial stress as a predictor of injury in elite junior soccer: A latent growth curve analysis. *J Sci Med Sport* 2014;17(4):366-70. doi: 10.1016/j.jsams.2013.10.242
31. Junge A, Rosch D, Peterson L, et al. Prevention of soccer injuries: A prospective intervention study in youth amateur players. *Am J Sport Med* 2002;30(5):652-59.
32. Pensgaard AM, Ivarsson A, Nilstad A, et al. Psychosocial stress factors, including the relationship with the coach, and their influence on acute and overuse injury risk in elite female football players. *BMJ Open Sport Exerc Med* 2018;4(1):e000317. doi: 10.1136/bmjsem-2017-000317
33. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. *Int J Surg* 2014;12(12):1495-99. doi: 10.1016/j.ijsu.2014.07.013
34. Walden M, Atroshi I, Magnusson H, et al. Prevention of acute knee injuries in adolescent female football players: cluster randomised controlled trial. *Bmj-British Medical Journal* 2012;344 doi: 10.1136/bmj.e3042
35. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Brit J Sport Med* 2006;40(3):193-201. doi: 10.1136/bjsem.2005.025270
36. Hägglund M, Waldén M, Bahr R, et al. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Brit J Sport Med* 2005;39(6):340-46.
37. Emery CA, Meeuwisse WH, Hartmann SE. Evaluation of risk factors for injury in adolescent soccer: implementation and validation of an injury surveillance system. *Am J Sport Med* 2005;33(12):1882-91.

- 1
2
3 38. Hardy GE, Shapiro DA, Haynes CE, et al. Validation of the general health questionnaire-12 using a
4 sample of employees from England's health care services. *Psychol Assess* 1999;11(2):159-65.
5 doi: 10.1037/1040-3590.11.2.159
6
7 39. Carver CS. You want to measure coping but your protocol's too long: Consider the brief COPE. *Int*
8 *J Behav Med* 1997;4(1):92-100. doi: 10.1207/s15327558ijbm0401_6
9
10 40. Vallerand RJ, Blanchard C, Mageau GA, et al. Les passions de l'Ame: On obsessive and harmonious
11 passion. *J Pers Soc Psychol* 2003;85(4):756-67. doi: 10.1037/0022-3514-85.4.756
12
13 41. Salminen S, Kouvonen A, Koskinen A, et al. Is a single item stress measure independently
14 associated with subsequent severe injury: a prospective cohort study of 16,385 forest
15 industry employees. *Bmc Public Health* 2014;14(1):543.
16
17 42. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration
18 of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre
19 (OSTRC) overuse injury questionnaire. *Br J Sports Med* 2013;47(8):495-502.
20
21 43. Ekman E, Frohm A, Ek P, et al. Swedish translation and validation of a web-based questionnaire
22 for registration of overuse problems. *Scand J Med Sci* 2015;25(1):104-9. doi:
23 10.1111/sms.12157
24
25 44. Von Korff M, Ormel J, Keefe FJ, et al. Grading the severity of chronic pain. *Pain* 1992;50(2):133-
26 49.
27
28 45. Dunn KM, Campbell P, Jordan KP. Validity of the visual trajectories questionnaire for pain. *J Pain*
29 2017;18(12):1451-58.
30
31 46. Dennis RJ, Finch CF, Elliott BC, et al. The reliability of musculoskeletal screening tests used in
32 cricket. *Phys Ther Sport* 2008;9(1):25-33. doi: 10.1016/j.ptsp.2007.09.004
33
34 47. Youdas JW, Bogard CL, Suman VJ. Reliability of goniometric measurements and visual estimates
35 of ankle joint active range of motion obtained in a clinical setting. *Arch Phys Med Rehab*
36 1993;74(10):1113-18. doi: 10.1016/0003-9993(93)90071-h
37
38 48. Ness BM, Sudhagoni RG, Tao H, et al. The reliability of a novel heel-rise test versus goniometry to
39 assess plantarflexion range of motion. *Int J Sports Phys Ther* 2018;13(1):19-27. doi:
40 10.26603/ijsp20180019
41
42 49. Konor MM, Morton S, Eckerson JM, et al. Reliability of three measures of ankle dorsiflexion range
43 of motion. *Int J Sports Phys Ther* 2012;7(3):279.
44
45 50. Frohm A, Heijne A, Kowalski J, et al. A nine-test screening battery for athletes: a reliability study.
46 *Scand J Med Sci* 2012;22(3):306-15. doi: 10.1111/j.1600-0838.2010.01267.x
47
48 51. Asker M, Walden M, Kallberg H, et al. A prospective cohort study identifying risk factors for
49 shoulder injuries in adolescent elite handball players: the Karolinska Handball Study (KHA
50 ST) study protocol. *BMC Musculoskelet Disord* 2017;18 doi: 10.1186/s12891-017-1852-2
51
52 52. Johnson KD, Kim KM, Yu BK, et al. Reliability of thoracic spine rotation range-of-motion
53 measurements in healthy adults. *J Athl Training* 2012;47(1):52-60.
54
55 53. Andre MJ, Fry AC, Heyrman MA, et al. A reliable method for assessing rotational power. *J*
56 *Strength Cond Res* 2012;26(3):720-24. doi: 10.1519/JSC.0b013e318227664d
57
58 54. Palmer TG, Uhl TL. Interday reliability of peak muscular power outputs on an isotonic
59 dynamometer and assessment of active trunk control using the chop and lift tests. *J Athl*
60 *Training* 2011;46(2):150-59. doi: 10.4085/1062-6050-46.2.150
55
56 55. Zois J, P Sharp A, Talukdar K, et al. The reliability of a rotational power assessment of the core. *J*
57 *Athl Enhanc* 2016;5(5)
58
59 56. Arumugam A, Mani R, Raja K. Interrater reliability of the craniocervical flexion test in
60 asymptomatic individuals- A cross-sectional study. *J Manipulative Physiol Ther*
2011;34(4):247-53. doi: 10.1016/j.jmpt.2011.04.011
57
58 57. James G, Doe T. The craniocervical flexion test: intra-tester reliability in asymptomatic subjects.
59 *Physiother Res Int* 2010;15(3):144-49.
60
61 58. Thorborg K, Bandholm T, Holmich P. Hip- and knee-strength assessments using a hand-held
dynamometer with external belt-fixation are inter-tester reliable. *Knee Surg Sport Tr A*
2013;21(3):550-55. doi: 10.1007/s00167-012-2115-2

- 1
2
3 59. Kelln BM, McKeon PO, Gontkof LM, et al. Hand-held dynamometry: Reliability of lower extremity
4 muscle testing in healthy, physically active, young adults. *J Sport Rehabil* 2008;17(2):160-70.
5 doi: 10.1123/jsr.17.2.160
6
7 60. Prather H, Harris-Hayes M, Hunt DM, et al. Reliability and agreement of hip range of motion and
8 provocative physical examination tests in asymptomatic volunteers. *PM R* 2010;2(10):888-95.
9 doi: 10.1016/j.pmrj.2010.05.005
10
11 61. Nussbaumer S, Leunig M, Glatthorn JF, et al. Validity and test-retest reliability of manual
12 goniometers for measuring passive hip range of motion in femoroacetabular impingement
13 patients. *BMC Musculoskelet Disord* 2010;11 doi: 10.1186/1471-2474-11-194
14
15 62. Sharma N, Sharma A, Sandhu JS. Functional performance testing in athletes with functional ankle
16 instability. *Asian J Sports Med* 2011;2(4):249.
17
18 63. Caffrey E, Docherty CL, Schrader J, et al. The ability of 4 single-limb hopping tests to detect
19 functional performance deficits in individuals with functional ankle instability. *J Orthop Sports*
20 *Phys Ther* 2009;39(11):799-806. doi: 10.2519/jospt.2009.3042
21
22 64. Vaseenon T, Gao Y, Phisitkul P. Comparison of two manual tests for ankle laxity due to rupture of
23 the lateral ankle ligaments. *Iowa Orthop J* 2012;32:9-16.
24
25 65. de Vries JS, Kerkhoffs G, Blankevoort L, et al. Clinical evaluation of a dynamic test for lateral ankle
26 ligament laxity. *Knee Surg Sport Tr A* 2010;18(5):628-33. doi: 10.1007/s00167-009-0978-7
27
28 66. Smith TO, Clark A, Neda S, et al. The intra- and inter-observer reliability of the physical
29 examination methods used to assess patients with patellofemoral joint instability. *Knee*
30 2012;19(4):404-10. doi: 10.1016/j.knee.2011.06.002
31
32 67. Moreau CE, Green BN, Johnson CD, et al. Isometric back extension endurance tests: A review of
33 the literature. *J Manipulative Physiol Ther* 2001;24(2):110-22. doi:
34 10.1067/mmt.2001.112563
35
36 68. Demoulin C, Vanderthommen M, Duysens C, et al. Spinal muscle evaluation using the Sorensen
37 test: a critical appraisal of the literature. *Joint Bone Spine* 2006;73(1):43-50. doi:
38 10.1016/j.jbspin.2004.08.002
39
40 69. Latimer J, Maher CG, Refshauge K, et al. The reliability and validity of the Biering-Sorensen test in
41 asymptomatic subjects and subjects reporting current or previous nonspecific low back pain.
42 *Spine* 1999;24(20):2085-89. doi: 10.1097/00007632-199910150-00004
43
44 70. Malone S, Owen A, Newton M, et al. The acute:chronic workload ratio in relation to injury risk in
45 professional soccer. *J Sci Med Sport* 2017;20(6):561-65. doi: 10.1016/j.jsams.2016.10.014
46
47 71. Nilstad A, Bahr R, Andersen TE. Text messaging as a new method for injury registration in sports:
48 A methodological study in elite female football. *Scand J Med Sci Sports* 2014;24(1):243-49.
49 doi: 10.1111/j.1600-0838.2012.01471.x
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2
3 This is a supplementary document describing the included tests in Karolinska football Injury
4 Cohort, KIC. Table S1 shows the test stations, number of test leaders and randomization of
5 the tests. The persons in the images have given their consent that the images will be used in
6 publications related to this study.
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8

9 **Calf heel raises**

10 Ankle plantarflexion (PF) muscle endurance is investigated using unilateral barefoot weight
11 bearing calf heel raises⁴⁶. Firstly, the player's maximal weight bearing PF range of motion
12 (ROM) is obtained by painting a reference mark on the player's heel at floor level and
13 registering the maximal height achieved during one calf heel raise with a metric ruler.
14

15 The player is thereafter instructed to perform repeated maximum unilateral heel raises until
16 failure, guided by a metronome to standardize the pace (1 second concentric-, 1 second
17 eccentric contraction). The player is allowed to have light contact with her fingers against a
18 wall. A repetition is considered approved on the basis whether knee extension is maintained,
19 and the reference mark on the player's heel levels with the registered maximal PF ROM
20 height on the ruler. The test leader registers the total number of approved repetitions and
21 discontinues the test when the player fails to reach the marked maximal height. The same
22 procedure is then conducted on the opposite foot. The order of execution is randomized prior
23 to the test.
24
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26



49 **Figure S1.** Calf heel raises.

51 **Active plantarflexion mobility**

52
53 Active PF ROM is measured with a clear plastic goniometer positioned at the lateral
54 malleolus, utilizing fibula and fifth metatarsal as reference marks^{47 48}. The player is positioned
55 in supine on an treatment table, with feet off the edge of the table. The player is instructed to
56 perform a sequence of six maximal active PF cycles starting from a neutral dorsiflexion (DF)
57 position, whilst maintaining extended knees throughout the movement. The test leader
58 measures and registers the maximal PF ROM in the final three cycles.
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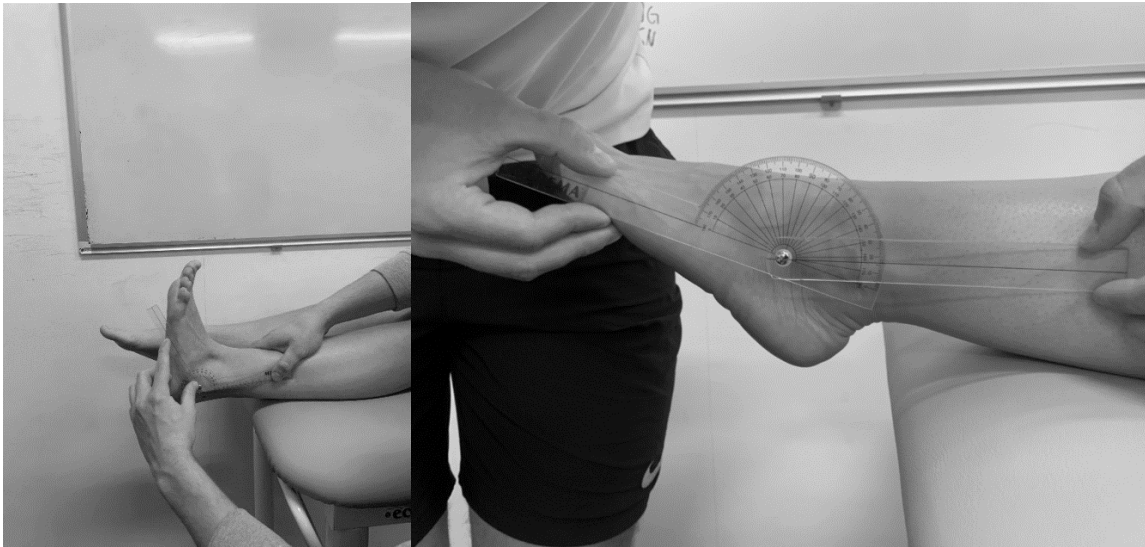


Figure S2. Active plantarflexion mobility execution. a) starting position in neutral dorsiflexion, b) end position in maximal active plantarflexion.

Weight bearing ankle dorsiflexion mobility

Weight bearing ankle DF ROM is measured in a standing lunge position with the player's foot placed upon a metric ruler 10 cm away from a wall to the player's greater toe^{46 49}. The player is instructed to lunge forward, directing the knee in line with her second toe, until contact with the wall is achieved; without allowing the heel to lift off the ground, which is continuously monitored through the availability to maintain a piece of paper against the foundation. Throughout the test, the player is allowed to provide balance by light contact with her fingers against the wall.

Firstly, three consecutive warm-up trials are performed from the 10 cm mark to familiarize the player with the test. Thereafter, the test leader measures the following three trials. In each trial, the player begins from the reference mark (10 cm) and progresses 1 cm away from the wall at a time, until unable to perform a successful repetition. If the player is unable to perform an approved repetition at the 10 cm reference mark, she is asked to progress 1 cm forward until able to complete a successful repetition. Once the player achieves knee-wall contact, the DF ROM is measured with a digital inclinometer (Clinometer, Plaincode, Stephanskirchen, Germany) and the distance from the wall to the greater toe is measured in cm in the repetition furthest away from the wall in each trial.



Figure S3. Weight bearing ankle dorsiflexion mobility.

Trunk mobility

Mobility in trunk rotation are measured in a cross-legged seated position, and in a lunge position with the player on a gym mat, graded with 5 degrees increments, from zero to one hundred and eighty degrees⁵⁰⁻⁵².

In the seated test (modified seated rotation test), the player is positioned at the center of the gym mat, in a cross-legged position with a wooden stick resting on the shoulders whilst keeping her arms crossed. If the player is unable to achieve the cross-legged sitting position, she is allowed to sit comfortable in an ordinary sitting position, which is noted by the test leader. Once in the starting position, the player is instructed to keep an upright posture and maximally rotate alternating between right and left for three times, whilst the test leader measures the rotational degrees in the end range.

The same procedure is thereafter repeated in a lunge position with the wooden stick resting on the player's shoulders. The player is positioned in a lunge position with her posterior knee at the center of the gym mat, and with her feet aligned on the zero-degree mark. Three consecutive maximal rotations are carried out alternating between right and left and is conducted in a lunge position for both the dominant, and non-dominant limb.

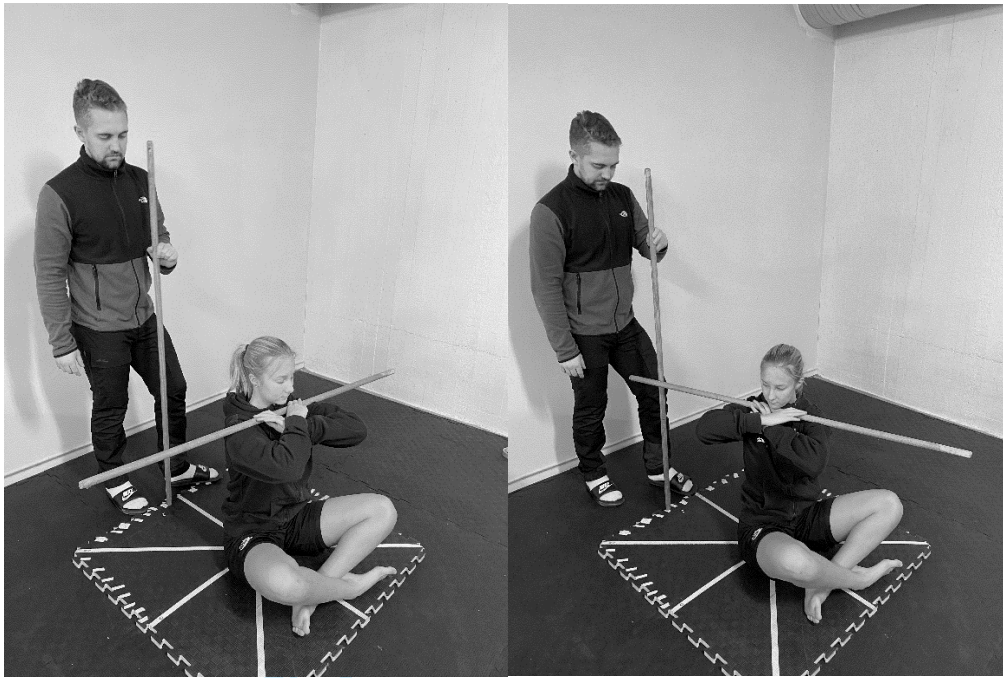


Figure S4. Modified seated rotation test. a) starting position, b) end position (right).

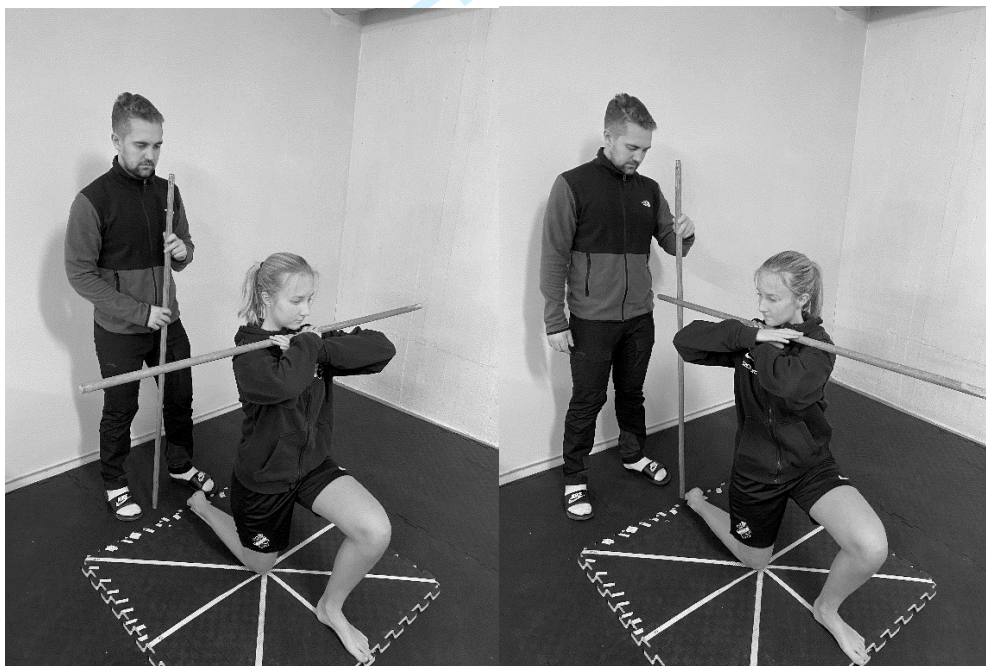


Figure S5. lunge rotation test. a) starting position left leg, b) end position (right).

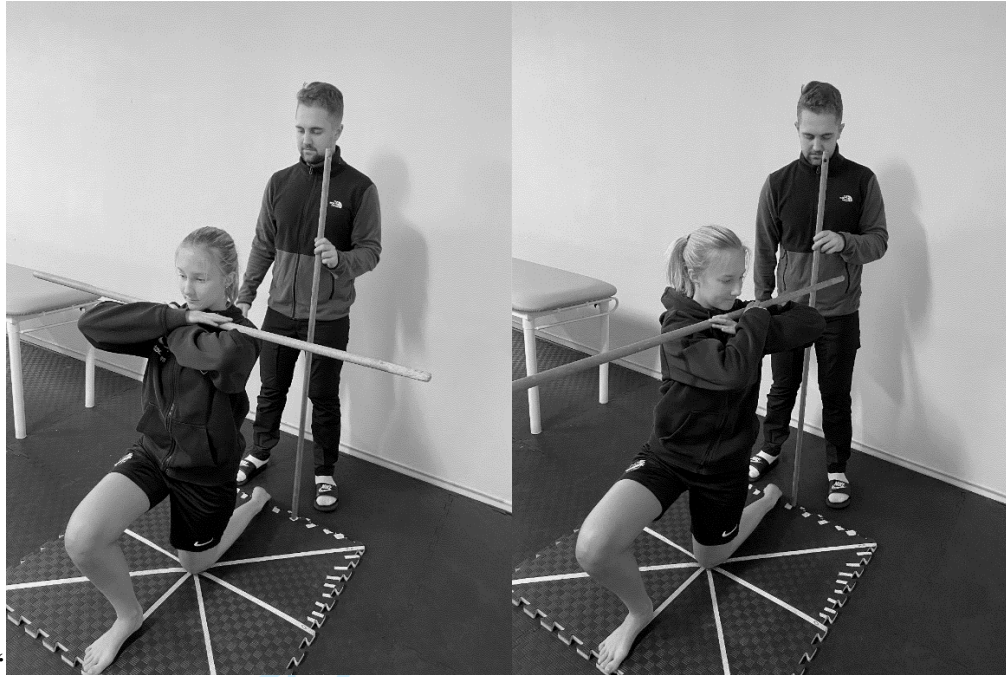


Figure S6. lunge rotation test. a) starting position right leg, b) end position (left).

Trunk strength

Isometric trunk rotational strength is measured in a modified standing wood chopper test utilizing a force gauge to evaluate force output (RS Pro Digital Force Gauge, RS Components Ltd., Corby, UK)⁵³⁻⁵⁵.

In a standing position with extended arms, the player holds a handle in shoulder height, which is attached to the force gauge. The test leader positions the player in a 30-degree trunk rotation in the horizontal plane towards the anchor point (see figure S7).

The player is thereafter instructed to maximally generate force through her trunk and isometrically rotate in the opposite direction for five seconds whilst maintaining straight arms. Three consecutive repetitions are conducted for both right and left, and the maximal force output generated is used in the analyses. The order of execution is randomized prior to performing the test.



Figure S7. Modified standing wood chopper test (isometric rotation to the right).

Deep neck flexor endurance

Deep neck flexor muscle endurance is assessed through a modified version of the Cranio-cervical flexion test (CCFT) with a pressure sensor (Stabilizer Pressure Bio-Feedback, Chattanooga Group inc, Hixon, TN)^{51 56 57}.

Prior to executing the test, the player is instructed in how to perform a correct cranio-cervical flexion motion in standing and supine position through a gentle 'head nodding' cue. The player is positioned in supine position on a treatment table with her hands placed upon her abdomen or at the side of the body and with her feet on the table, with flexed hips and knees. With the player's head and neck in a neutral position, the pressure stabilizer is positioned sub-occipitally, and inflated to a baseline pressure of 20 mmHg. Firstly, a pre-test is conducted and later an endurance test.

During the pre-test, the player is instructed to perform a gentle cranio-cervical flexion to increase the pressure starting from a baseline of 20 mmHg with 2 mmHg increments to a maximum of 30 mmHg. 3x3 second contractions are carried out at each target pressure (TP) with a three second rest in between each contraction whilst the test leader monitors for potential compensational strategies: excessive use of global neck musculature, chin jerking, cervical spine retraction, jaw clenching, breath holding and a pressure loss of ≥ 2 mmHg. A stopwatch time the contractions and visual feedback of pressure level is provided by the test leader who holds the manometer dial so that both the player and the test leader can read it throughout the procedure.

The endurance test is conducted if the player completes each of the five TP (22, 24, 26, 28 and 30 mmHg) without exhibiting any of the compensational strategies and/or experiencing pain during the pre-test. During the endurance test, the same setup and procedure as in the

pre-test is carried out. The player is now instructed to hold each contraction at the TP for 3x10 seconds with a ten second rest in between contractions. The highest completed TP with a full set of 3x10 seconds contractions is registered by the test leader and later used for analysis.



Figure S8. Modified cranio-cervical flexion test.

Hip- and knee strength

Isometric hip flexion, extension, adduction, and abduction strength as well as eccentric hip abduction and adduction and isometric knee extension strength are measured with a hand-held dynamometer (HHD) (MicroFet2, Hoggan Health Industries inc. West Jordan, UT, USA)^{58 59}.

Prior to executing the strength tests, two submaximal isometric contractions in each direction are performed to familiarize the player with the procedures. Three isometric contractions with gradually increasing force output for five seconds, and three maximal eccentric contractions for three seconds are performed in the isometric and eccentric tests, respectively, with a 10 second rest in between each contraction. The maximal force output for each position is registered by the test leader and later used for analysis. The order of execution and starting side is randomized prior to performing the tests at the particular test station (see table S1).

Isometric hip flexion strength

The player is positioned in a seated position at the edge of an treatment table, with 90-degrees of hip- and knee flexion. The HHD is positioned two centimeters proximal to the patella, and are externally fixated with a belt, which is secured under the leg of the treatment table, limiting hip flexion movement. The player is instructed to perform three isometric contractions on each leg.

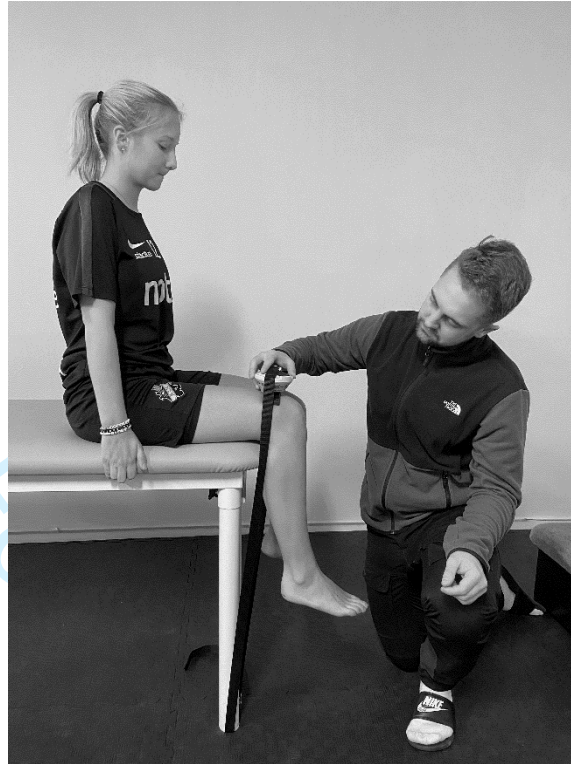


Figure S9. Isometric hip flexion strength (right hip).

Isometric knee extension strength

Seated in the same position as during the isometric hip flexion strength test, with a slightly extended knee joint, the HHD is positioned two centimeters proximal to the malleoli on the anterior aspects of the player's tibia and are externally fixated with a belt. The player is instructed to perform three isometric contractions on each leg respectively.

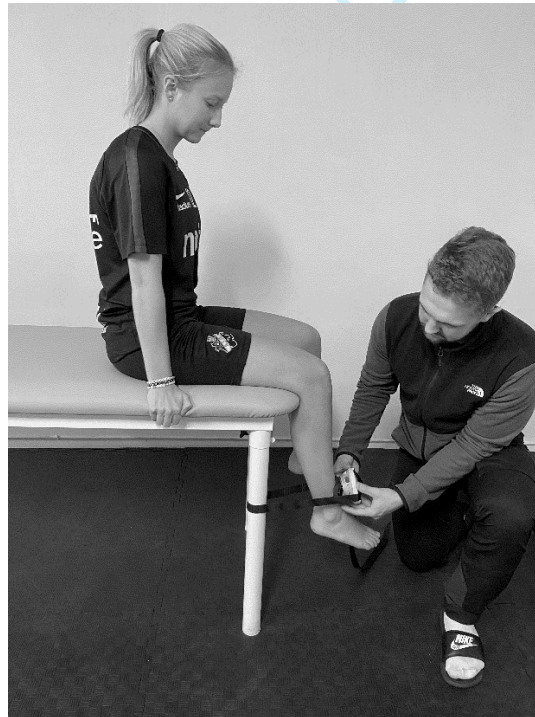


Figure S10. Isometric knee extension strength (right leg).

Isometric hip extension strength

With the player positioned in a prone position on a treatment table and with her feet off the edge of the table, the test leader externally fixates the HHD two centimeters proximal to the malleoli with a belt. Furthermore, the player is instructed to perform three maximal isometric contractions on each leg respectively



Figure S11. Isometric hip extension strength (left hip).

Isometric hip abduction strength

The player is positioned in a supine position on an treatment table, with the tested leg extended, and the non-tested leg flexed. The test leader positions and fixates the HHD two centimeters proximal to the lateral malleolus with a belt, which limits hip abduction movement. Thereafter, the player is instructed to perform three maximal isometric hip abductions, whilst the test leader measures the force output for both the left, and right side.



Figure S12. Isometric hip abduction strength (left hip).

Isometric hip adduction

Lying in the same position as during the isometric hip abduction the test leader places and fixates the HHD two centimeters proximal to the medial malleolus with a belt. Consequently, the player executes three maximal isometric hip adductions on the left and right side, whilst the test leader registers the force output.



Figure S13. Isometric hip adduction strength (right hip).

Eccentric hip abduction strength

The player is in a side-lying position on an treatment table with the test leg extended, and the opposite leg flexed to 90 degrees in the knee- and hip joint, whilst a neutral hip position is maintained. The player is subsequently instructed to place the test leg in approximately 40 degrees of hip abduction, and the test leader places a HHD one centimeter proximally to the lateral malleolus. The test leader initiates the test by saying “push”, and when the player has built up a maximal isometric contraction, the test leader begins to apply a downward directed force with the HHD whilst the player resists eccentrically for five seconds. Three repetitions are carried out on both the right and leg left, and the maximal force output is later used for analysis.



Figure S14. Eccentric hip abduction strength. a) starting position (right hip), b) end position (right hip).

Eccentric hip adduction strength

The player is positioned in the same manner as in the eccentric hip abduction strength test, with the tested leg extended, and the non-tested leg flexed in the hip- and knee joint. Thereafter, the player is instructed to place the test leg in a maximal adduction position, whereupon the test leader positions a HHD one centimeter proximally to the medial malleolus. The test is initiated when the test leaders says “push”, whereupon a downward directed force is applied with the HHD whilst the player resists eccentrically for five seconds. Three consecutive trials are conducted on both sides, and the test leader registers the force output.



Figure S15. Eccentric hip abduction strength. a) starting position (left hip), b) end position (left hip).

Hip mobility

Measures of passive hip ROM in flexion, extension, abduction, internal- and external rotation are obtained using a universal clear plastic goniometer^{60 61}. Three consecutive measurements for each position are performed for both the dominant and the non-dominant leg and the mean value for each position is later used for analysis. If the same value is obtained during the first and second measurement for a particular movement, a third one is not performed. The order of execution (side and movement) is randomized prior to performing the measures.

Passive hip flexion ROM

The player is positioned in supine position on a treatment table. With the player's leg held in a 90-degree knee flexion, test leader 1 moves the player's leg into a passive hip flexion until a firm end feel is achieved, and a posterior pelvic tilt occurs. Once the end feel is achieved, test leader 2 places the center of the goniometer at the greater trochanter and aligns one of the goniometer's arms with the player's femur, and the other one horizontally with the treatment table to read the goniometer. Three consecutive measures are conducted on each hip.



Figure S16. Passive hip flexion ROM (left hip).

Passive hip abduction ROM

The player is in a supine position on an treatment table with extended legs. While palpating the player's ipsilateral anterior superior iliac spine, test leader 1 holds the player's leg by the ankle and moves the leg into passive hip abduction until a firm end feel is achieved, and motion is felt at the pelvis. Thereafter, test leader 2 positions the goniometer at the player's hip, aligning the lever arms with the player's anterior superior iliac spine and femur, and reads the degrees of abduction. The test is repeated three times on each hip.

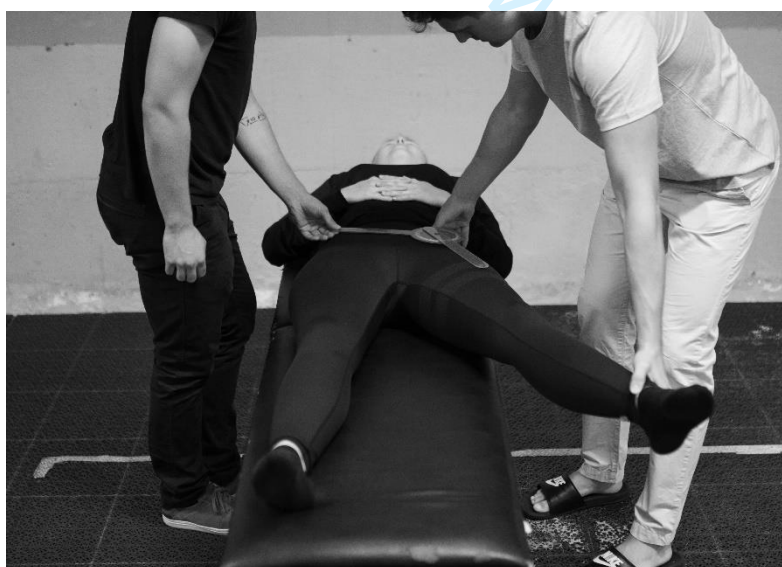


Figure S17. Passive hip abduction ROM (left hip).

Passive hip extension ROM

In prone position with extended legs, test leader 1 fixates the player's pelvis by placing a hand at the ipsilateral posterior superior iliac spine. Thereafter, while holding the player's leg at the knee, test leader 1 moves the player's leg into passive hip extension, until an end feel is achieved, indicated by an anterior tilt of the pelvis. Test leader 2 measures the degrees of passive hip flexion with the goniometer's center positioned at the greater trochanter, and the lever arms in line with the player's femur and the treatment table horizontally. Three measures are performed on each leg.



Figure S18. Passive hip extension ROM (right hip).

Passive hip internal- and external rotation ROM

In prone position, the player's leg is flexed to 90 degrees in the knee joint. Consequently, test leader 1 fixates the pelvis by placing his/her hand on the player's posterior superior iliac spine and performs a passive internal and external hip rotation, respectively, until an end feel is felt, indicated by an anterior pelvic tilt. Test leader 2 measures the degree of rotational mobility with a goniometer positioned at the knee, with the levers aligned with the player's tibia and with the treatment table horizontally. Three consecutive measures are conducted on each leg.



Figure S19. Passive hip rotational ROM (right hip). a) internal rotation, b) external rotation.

Jump performance tests

To assess the player's unilateral jump performance, the One-leg Long Box Jump Test (OLLBJ) and square hop test are performed^{62 63}. A 40x40 cm square is marked on the foundation and later utilized as a reference mark in both tests. During the jump tests, players wear indoor sporting shoes.

One-leg long box jump test (OLLBJ)

Firstly, the starting position, i.e. the distance player's jump from to the 40x40 cm square is calculated by dividing the player's height in cm with 1.6 (height/1.6 = distance to the square). The player is instructed to stand on one leg at the starting position, and to perform a one-legged jump aiming inside the boundaries of the 40x40 cm square, and to maintain balance after landing. A trial is considered approved on the basis that the player land inside the 40x40 cm square, and adequately maintains balance after landing. The player performs three warm up trials on each leg, to familiarize with the procedure, and later five consecutive test trials. The test leader registers the total number of approved trials on each leg (0 to 5).

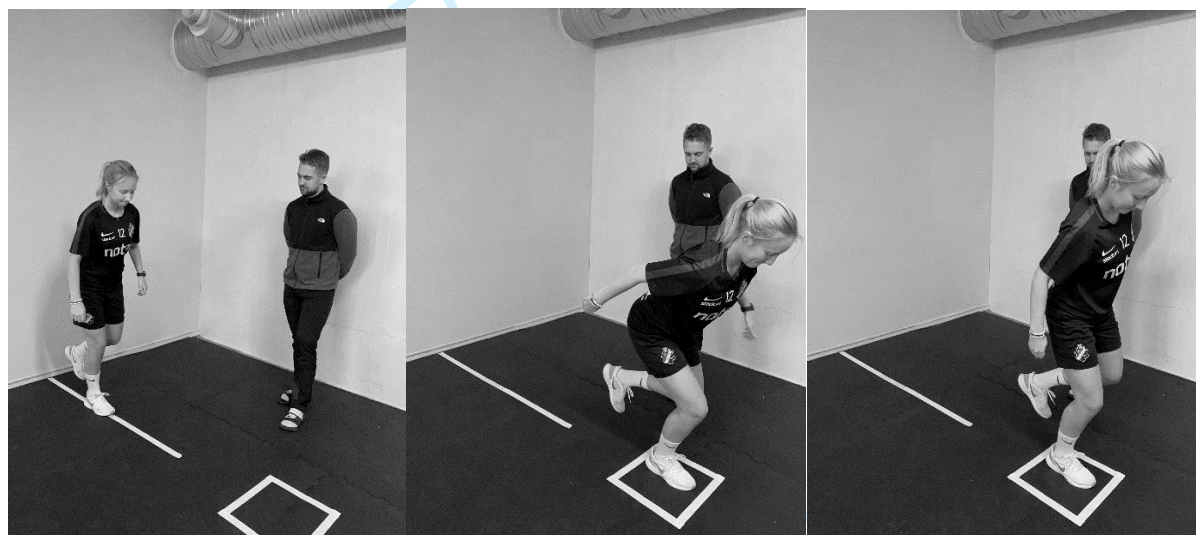


Figure S20. One-leg long box jump test (right leg). a) starting position, b) landing, c) balance maintained.

Square hop test

During the square hop test, the player is instructed to hop on one leg in and out of the 40x40 cm square as many times as possible for 15 seconds in a clockwise direction, timed with a stopwatch, whilst the test leader registers the number of approved hops. A hop is classified as approved on the basis whether the player begins a hop in the starting position (outside the square) and then executes the short hop task inside the square and then in the correct direction outside the square. Prior to the test, the player performs two warm up trials on each foot.

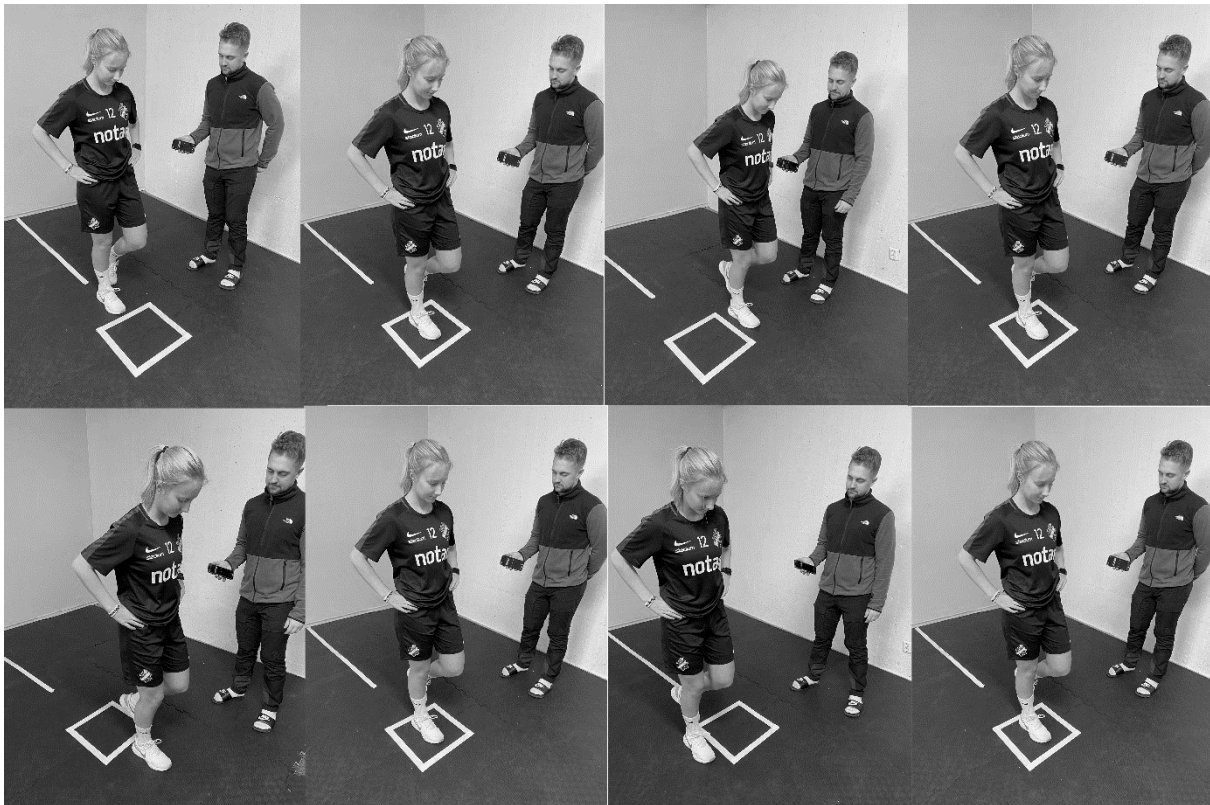


Figure S21. A series of square hop tests illustrated on the player's right leg.

Ankle- & knee stability

Modified anterior drawer test (ankle)

To assess talocrural stability or pain, a modified anterior drawer test is performed^{64 65}. With the player in supine position with the test limb in knee flexion and the on the treatment table, the test leader applies an anteriorly directed force to the player's talus and a concurrent posteriorly directed force to the calcaneus. The test is conducted once on both the dominant and non-dominant foot and are considered positive if the player experiences any pain or discomfort during the procedure.



Figure S22. Modified anterior drawer test (right ankle).

Modified Fairbank's apprehension test (patellofemoral)

A modified version of Fairbank's apprehension test is conducted to evaluate stability or pain in the patellofemoral joint⁶⁶. In supine position with extended legs, the test leader applies a laterally and subsequently medially directed force to the patella. The test is considered positive if the player experiences any pain or discomfort during the test, and/or an involuntary contraction of the quadriceps musculature. The test is carried out once on the player's dominant and non-dominant limb.



Figure S23. Modified Fairbank's apprehension test (left patellofemoral joint).
a) lateral translation, b) medial translation.

Isometric back extensor endurance

Isometric back extensor endurance is assessed by a modified Sorensen test⁶⁷⁻⁶⁹. In prone position, the player's anterior superior iliac spine is positioned at the edge of the treatment table. The player's lower body is supported to the treatment table with three straps positioned over the player's ankles, knees, and pelvis. Whilst the test leader fastens the player's lower body to the treatment table with the three straps, the player uses a box/stool for support.

The player is thereafter instructed to keep her arms folded across the chest and isometrically maintain the upper body in a horizontal position until failure whilst the test leader register the time elapsed. A digital inclinometer (Clinometer, Plaincode, Stephanskirchen, Germany) is placed upon a metric ruler at the level of the 5th vertebra of the thoracical spine to monitor sagittal plane movement. If the player's upper body deviate greater than 10 degrees in the sagittal plane on more than two occasions and/or experience pain during the procedure, the test is stopped. Prior to the test, the player completes a shorter warmup trial of 5 seconds to orient the desired sagittal plane target angle.



Figure S24. Modified Sorensen test.

Table S1. Test stations, number of test leaders and randomization of the physical test protocol.

Test	Test station	Number of test leaders	Randomized order of execution
Calf heel raises	1	1	Yes
Active plantarflexion mobility	2	1	No
Weight bearing ankle dorsiflexion mobility	2	1	No
Ankle- & Knee stability	2	1	No
Hip mobility	3	2	Yes
Isometric Knee extension, hip flexion & extension strength	4	2	Yes
Trunk mobility	5	1	No
Trunk strength	5	1	Yes
Isometric and eccentric hip abduction and adduction	6	2	Yes
Deep neck flexor endurance	7	1	n/a
Functional performance tests	8	1	Yes
Isometric back extensor endurance	9	1	n/a

n/a-not applicable

BMJ Open

Study protocol for a prospective cohort study identifying risk factors for sport injury in adolescent female football players: the Karolinska football Injury Cohort (KIC)

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Secondary Subject Heading:	Epidemiology
Keywords:	Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY, SPORTS MEDICINE, EPIDEMIOLOGY

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Manuscripts

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3 **Study protocol for a prospective cohort study identifying risk factors for**
4 **sport injury in adolescent female football players: the Karolinska football**
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8 **Injury Cohort (KIC)**
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ABSTRACT

Introduction Football is a popular sport among young females worldwide, but studies concerning injuries in female players are scarce compared with male players. The aim of this study is to identify risk factors for injury in adolescent female football players.

Methods and analysis The Karolinska football Injury Cohort (KIC) is an ongoing longitudinal study that will include approximately 400 female football academy players 12-19 years old in Sweden. A detailed questionnaire regarding demographics, health status, lifestyle, stress, socioeconomic factors, psychosocial factors, and various football-related factors are completed at baseline and after one year. Clinical tests measuring strength, mobility, neuromuscular control of the lower extremity, trunk, and neck are carried out at baseline. Players are followed prospectively with weekly e-mails regarding exposure to football and other physical activity, health issues (such as stress, recovery, etc.), pain, performance, and injuries via the Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O). Players who report a substantial injury in the OSTRC-O, i.e., not being able to participate in football activities, have reduced their training volume performance to a moderate or major degree, are contacted for full injury documentation. In addition to player data, academy coaches also complete a baseline questionnaire regarding coach experience and education.

Ethics and dissemination The study was approved by the Regional Ethical Review Authority at Karolinska Institutet, Stockholm, Sweden (2016/1251-31/4). All participating players and their legal guardians give their written informed consent. The study will be reported in accordance with the Strengthening the Reporting of Observational studies in Epidemiology (STROBE). The results will be published in peer-reviewed academic journals and disseminated to the Swedish football movement through stakeholders and media.

Keywords: Acute injuries, bio-psychosocial factors, girls, gradual onset injuries, soccer, youth.

ARTICLE SUMMARY

Strengths and limitations of this study

- A strength is the bio-psychosocial and multi professional perspective of the risk of injuries in young female football players and factors of importance for not being injured, even though the bio-psychosocial factors are not equal included
- Strengths are also the large sample size and the robust data collection of exposures, potential confounding factors, potential effect measure modifiers and outcome.
- A potential limitation is the risk of misclassification of time varying exposures and outcomes in the weekly self-reported data collection.
- Using e-mails and SMS for weekly reports might decrease the response rates and thereby increase the risk of selection bias in the results. If the response turns out to be low, there is a risk of selection bias in the risk analyses

INTRODUCTION

Four million females worldwide are registered football players, of which 2.5 million are under 17 years old according to Fédération Internationale de Football Association (FIFA)¹. Studies regarding injuries in female football players are fewer compared to the number of studies in male football players²⁻⁴. In brief, these studies show that common injuries in female football players are joint and ligament injuries to the knee and ankle joints as well as muscle and tendon injuries of the thigh. In addition, there is a particular concern for concussions and anterior cruciate ligament (ACL) injuries in female players^{3 5-8}.

Female football players have more absence days from football due to injuries compared to male players⁸, and long-term consequences of injuries might be considerable for young football players⁹. For players with a history of injury, the risk of osteoarthritis in lower extremity joints are high and greater than in the general population^{10 11}. Injuries may also lead to premature career ending¹², and mental health problems¹³. Identifying risk factors for injury is, therefore, an important step towards reduction of injury risk¹⁴. To identify possible risk factors, well-designed prospective cohort studies are needed^{15 16}. Specifically, the suggested risk factors in this setting can be classified as bio-psychosocial factors (see Wiese-Bjornstal for bio-psychosocial view on a sport injury risk profile)¹⁷. Biological risk factors for injury in female players are previous injury^{7 18-20}, a hamstring/quadriceps ratio of less than 55 %, increased body mass index (BMI), as well as results of plyometric tests e.g., poor performance in drop jump landing test is associated with increased risk of ankle injury²¹. Other biological risk factors associated with an increased risk of injury during the season are young age^{6 18}, physical complaints at the beginning of the season¹⁸, familial disposition such as a parent/sibling¹⁸, or a twin²² with knee injury, and lower level of preseason aerobic fitness^{23 24}. Findings regarding joint hypermobility as a risk factor in female players are inconclusive in older studies^{23 25}, although no association was shown in more recently

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3 published studies^{26 27}. Risk factors for back pain in adolescents include rapid growth rate, and
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5 tight muscle imbalance²⁸, but risk factors for football related back/neck injuries in young
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7 females are not known. Psychological risk factors reported includes somatic trait anxiety,
8
9 mistrust, ineffective coping²⁹, life event stress³⁰, and perceived mastery climate²⁰. Social
10
11 factors that influenced the risk for injury in female athletes are coaches' and player's
12
13 education regarding injury prevention strategies³¹, stress from teammates and coaches^{20 29 32},
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15 and for back pain in adolescents; smoking²⁸. In football, an identified situational specific risk
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17 factor is the playing positions defender and strikers¹⁹.
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23 In summary, most knowledge about risk factors for injuries in adolescent female football
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25 players consists of isolated factors, and lack of using multidisciplinary and bio-psycho-social
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27 perspectives. Hence, the overall aim of the Karolinska football Injury Cohort study (KIC) is to
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29 identify risk factors for injuries in adolescent female football players from a bio-psycho-social
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31 perspective. Specific aims are to determine the incidence of injuries in young female football
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33 players and to identify modifiable risk factors for such injuries. Finally, our aims include to
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35 describe changes in muscle strength and range of motion over a year, trajectories of pain, and
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37 to identify important factors for not being injured over a year.
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METHODS AND ANALYSIS

This is a prospective observational cohort study designed in agreement with Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines³³.

Study setting and participants

Football clubs with adolescent female academy players aged 12 to 19 years, participating in Swedish divisions 1-2 for girls in the largest regions, are eligible to participate in the study.

Most players will be recruited in Stockholm. The district of Stockholm consists of 140 teams and approximate 2520 female players, 13-19 years old. Clubs which meet the inclusion criteria are contacted and invited to participate and are given oral and written information.

Clubs which choose to take part in the study are provided with a more detailed oral and written information in the presence of players, legal guardians, and coaches.

A cohort of approximately 400 adolescent academy players will be recruited. An internal pilot study of 63 football players has been conducted to test the infra-structure and the implementation of the study, with satisfactory results (unpublished data).

Baseline measurements

Questionnaires

The baseline questionnaire covers potential risk factors for the aetiology of sport injuries as well as information about players' general health status. Players are surveyed in various areas, including *health*: health problems (e.g. illness), medication, age at menarche, amenorrhoea, *lifestyle*: sleep patterns, eating habits, food supplements, tobacco as smoking or Swedish snus (snuff) and alcohol, and *socioeconomic* factors: guardians' education. *Included football-related factors* are: training and match play exposure, playing position, dominant limb, years of experience, other sports participation, injury preventive strategies (e.g. the Swedish injury prevention warmup programme Knee Control)³⁴, and type of turf at the home facilities

(artificial or natural grass) according to guidelines for football studies³⁵⁻³⁷. *Psychosocial factors* are surveyed using: the modified General Health Questionnaire-12 (GHQ-12) consisting of 12 items regarding self-reported general psychological health using a four-point Likert scale³⁸, coping assessed by a 28 item self-report questionnaire that measure effective and ineffective strategies to cope with stressful events using a four-point Likert scale (Brief COPE)³⁹, player's passion to sport measured in harmonious and obsessive passions using a 14 item questionnaire with a seven-point Likert scale (Passion scale)⁴⁰, education in sport psychology, regularly seeing a sport psychologist/mental coach and perceived stress (single item question)⁴¹. *Previous injury history*: injuries occurring within the previous six months prior to inclusion are captured using a modified Swedish version of the validated psychometric instrument Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O)^{42 43}. *Back and neck pain* is covering the frequency, intensity, disability of low back pain (LBP) and upper back pain/neck pain (UBNP) and corresponding longitudinal trajectories the preceding 6-months using modified versions of The Chronic Pain Questionnaire (CPQ)⁴⁴ and Visual Trajectories Questionnaire- Pain (VTQ-P)⁴⁵, respectively. In addition, coaches in the included teams are surveyed regarding their education, years of experience, the use of warmup and stretching regime and implementation of injury prevention programmes.

Physical test protocol

The physical test protocol includes several tests that are considered valid, reliable, and field friendly; performed in approximately 60 minutes/player. The protocol comprises measurements of strength, mobility and control of lower extremity, trunk and neck and also include anthropometric measurements (height, weight and leg length). The protocol is briefly outlined below, however further details including visual presentations is available in the

1
2
3 electronic supplementary file (Supplement 1).
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6 All test procedures are conducted in indoors facilities during weekends. The physical tests are
7
8 divided into nine test stations with 1-2 test leaders each (Supplement 1). Hitherto, 52
9
10 clinically experienced test leaders have been involved in data collection. They were trained by
11
12 MA, VL, NW and the previous test leader in charge of the station to ensure consistent
13
14 execution and reliability. Information and instructions given to the players regarding the tests
15
16 are standardised, and test leaders refrain from coaching or encouraging the players in any way
17
18 during the procedures.
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23 A maximum of nine players are tested per session (i.e. one at each station) and are informed
24
25 to train and compete as usual prior to testing. Players are informed to refrain from certain tests
26
27 that evoke pain, provoke ongoing injuries or other health-related issues. Prior to performing
28
29 the physical tests, players complete a standardised seven-minute warm-up programme
30
31 comprising four minutes of jogging, 10 x 1 body weight squats, 10 x 1 body weight squat
32
33 jumps, and 10 x 1 unilateral body weight lunges. Following the warm-up session, players are
34
35 randomly assigned to a starting test station and subsequently follow a predefined order.
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39 *Calf heel raises*

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42 Ankle plantarflexion (PF) muscle endurance is investigated using unilateral weight bearing
43
44 calf heel raises⁴⁶. The player is instructed to perform maximum unilateral barefoot heel raises
45
46 continuously to failure, guided by a metronome to standardise the pace (1 second concentric-,
47
48 1 second eccentric contraction). The test leader registers the number of accomplished
49
50 repetitions and discontinues when the player fails to reach the marked target height. The same
51
52 procedure is then conducted on the opposite foot.
53
54

55 *Active plantarflexion mobility*

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57
58 Active PF range of motion (ROM) is measured with a universal goniometer in supine position
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2
3 utilizing fibula and fifth metatarsal as reference marks^{47 48}. The player is instructed to
4
5 maintain extended knees throughout the movement, and to perform a sequence of six maximal
6
7 active PF cycles from a neutral dorsiflexion (DF) position, of which the final three trials are
8
9 registered.
10

11 12 *Weight bearing ankle dorsiflexion mobility*

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14
15 Weight bearing ankle DF ROM is measured in a lunge position with the player's foot placed
16
17 upon a metric ruler 10 cm away from a wall^{46 49}. The player is instructed to lunge forward,
18
19 until contact with the wall is achieved without allowing the heel to lift off the ground. Three
20
21 warm-up trials are performed from the 10 cm mark to familiarize the player with the test.
22
23 Thereafter, the test leader measures the following three trials. From the 10 cm reference mark,
24
25 the player progresses 1 cm away at a time from the wall until unable to perform a successful
26
27 repetition. If unable to perform a successful repetition at the 10 cm reference mark, she is
28
29 asked to progress 1 cm forward until able to complete a successful repetition. The maximal
30
31 DF ROM is measured with a digital inclinometer (Clinometer, Plaincode, Stephanskirchen,
32
33 Germany) and distance from the wall to the greater toe is measured in cm.
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38 39 *Trunk mobility*

40
41 Trunk rotation mobility is measured in a modified seated rotation test, and a in a lunge
42
43 position on a gym mat graded with 5 degrees increments⁵⁰⁻⁵². The player is instructed to
44
45 maximally rotate alternating between right and left, in a cross-legged position and
46
47 subsequently in a lunge position on the dominant, and non-dominant limb whilst the test
48
49 leader measures the rotational degrees in the end range. Three repetitions are performed in
50
51 each direction during the three separate positions, and the mean value for each position is later
52
53 used for analysis.
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57 58 *Trunk strength*

1
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3 Isometric trunk rotational strength is measured in a modified standing wood chopper test
4
5 utilising a force gauge to evaluate force output (RS Pro Digital Force Gauge, RS Components
6
7 Ltd., Corby, UK)⁵³⁻⁵⁵. In this modified test, the player holds a handle attached to the force
8
9 gauge in shoulder height in a standing position. The player is instructed to generate force
10
11 through her trunk and rotate for five seconds whilst maintaining straight arms. Three
12
13 consecutive repetitions are conducted in each direction and the maximal force output is later
14
15 used for analysis.
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18 19 *Deep neck flexor endurance*

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21
22 Deep neck flexor muscle endurance is assessed through a modified version of the Cranio-
23
24 cervical flexion test (CCFT) with a pressure sensor (Stabilizer Pressure Bio-Feedback,
25
26 Chattanooga Group Inc, Hixon, TN)^{51 56 57}. The test consists of a pre-test and an endurance
27
28 test. In the pre-test the player is positioned in a supine position on an examination table and
29
30 are instructed to slightly push the neck against the pressure sensor to increase the pressure and
31
32 then maintain the pressure for 3 × 3 seconds, with a 3 second rest in between each contraction,
33
34 at a specific target pressure (TP), starting at 20 mmHg. If the player can perform this task, she
35
36 is instructed to increase the pressure to 24 mmHg and keep the pressure for another 3 × 3
37
38 seconds. This is repeated with a 2-mmHg increase until the player reaches 30 mmHg. If the
39
40 player can perform the pre-test the endurance test is subsequently performed. During the
41
42 endurance test, the same setup and procedure as in the pre-test is carried out. However, the
43
44 player is instructed to hold each contraction at the TP for 3 x 10 with a 10 second rest in
45
46 between contractions. The highest completed TP with a full set of 3 x 10 seconds contractions
47
48 is later used for analysis.
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53 54 *Hip and knee strength*

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56
57 Isometric hip flexion, extension, adduction and abduction strength as well as eccentric hip
58
59 abduction and adduction strength are measured with a hand-held dynamometer (HHD)
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3 (MicroFet2, Hoggan Health Industries inc. West Jordan, UT, USA)^{58 59}. Furthermore,
4
5 isometric knee extension strength is measured with a HHD and the player in a seated position
6
7 with the knee joint in 90-degrees of flexion. Prior to executing the strength tests, two
8
9 submaximal isometric contractions in each direction are performed to familiarize the player
10
11 with the procedures. Three isometric contractions with gradually increasing power output for
12
13 five seconds, and three maximally eccentric contractions for three seconds are performed in
14
15 the isometric and eccentric tests, respectively, with a 10 second rest in between contractions.
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19 The maximal power output for each position is later used for analysis.
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22 *Hip mobility*

23
24 Measures of passive hip ROM in flexion and abduction in prone position and extension,
25
26 internal- and external rotation in supine position is obtained using a universal goniometer^{60 61}.
27
28 Three consecutive measurements for each position are performed for both the dominant and
29
30 the non-dominant leg, and the mean value for each position is later used for analysis.
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33 *Functional performance tests*

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36 To assess the player's unilateral jump performance, the One-leg Long Box Jump Test
37
38 (OLLBJ) and square hop test are performed^{62 63}. A 40 x 40 cm square is marked on the
39
40 foundation and later utilised as a reference mark in both tests.
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43
44 In the OLLBJ, the starting position are calculated by dividing the player's height (cm) with
45
46 1.6 (height / 1.6). Thereafter, the player is instructed to stand on one leg on the starting
47
48 position and then jump on one leg directed inside the boundaries of the square and maintain
49
50 balance after landing. Three warm up trials and five consecutive test trials are performed on
51
52 each leg. The total number of approved trials are registered by the test leader.
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56 During the square hop test, previously described in detail^{62 63}, the player is instructed to jump
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58 on one leg in and out of the square as many times as possible for 15 seconds in a clockwise
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3 direction, timed with a stopwatch whilst the test leader registers the number of approved
4 jumps. The player performs two warm up trials on each foot prior to executing the test.
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7 8 *Ankle and knee stability* 9

10 To assess stability of player's talocrural joints, a modified anterior drawer test is employed⁶⁴
11
12 ⁶⁵. Furthermore, a modified version of Fairbank's apprehension test is utilised to evaluate the
13 player's stability in the patellofemoral joint⁶⁶. The tests are conducted on both the dominant
14 and non-dominant foot and knee and are considered positive if the player experience any pain
15 or discomfort during the examination, and/or an involuntary contraction of the quadriceps
16 musculature occur during the Fairbank's apprehension test.
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24 25 *Isometric back extensor endurance* 26

27 Isometric back extensor endurance is assessed by the modified Sorensen test⁶⁷⁻⁶⁹. In this
28 previously described modified test^{67 68}, the player's lower body is supported by an examination
29 table in prone position with three straps and the anterior-superior iliac spine is aligned with
30 the edge of the table. The player is instructed to keep her arms folded across the chest
31 throughout the procedure and isometric maintaining the upper body in a horizontal position
32 until failure. The test leader registers the time elapsed until failure. A digital inclinometer
33 (Clinometer, Plaincode, Stephanskirchen, Germany) is placed upon a metric ruler at the level
34 of th5 in the thoracic spine to monitor sagittal plane movement. Prior to the assessment, the
35 player completes a shorter warmup trial to orient the desired sagittal plane target angle.
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49 **Follow-up measurement and outcome** 50

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52 Follow-up measurements are collected prospectively during one year from the baseline. In the
53 weekly online questionnaire, the players are asked to answer questions regarding new and
54 ongoing injuries, LBP and UBNP intensity, social support, perceived stress, recovery, and to
55 be able to consider workload, number of training and match play hours/week⁷⁰. To assess
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3 whether players sustain football related injuries throughout the follow-up period, the Swedish
4 version of OSTRC-O is employed and included in the weekly online questionnaire^{42 43 71}. Two
5
6 study specific adaptations were made to the OSTRC-O. Firstly, a question regarding
7
8 absence/reduced participation in training/match due to reasons not related to injuries was
9
10 added. Secondly, the option to specify injuries in different anatomical localisations in the
11
12 lower- and upper extremity, back, neck, head and abdomen was included.
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16
17 Football related injuries reported with the OSTRC-O in the weekly online questionnaire
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19 leading to moderate or severe reductions in participation/and or sports performance or
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21 complete inability to participate in sport are classified as a substantial injury in this study⁴².
22
23 Players reporting new substantial injuries are contacted via telephone by a clinically
24
25 experienced research assistant to answer a standardised interview with questions concerning
26
27 the injury such as: injury mechanism, localisation, type, time-loss, re-injury, diagnosis, and
28
29 medical care. Injuries are divided into acute and gradual onset. An acute injury is defined as a
30
31 result from a specific, identifiable event, whereas injuries with gradual onset are defined as an
32
33 injury without a single, identifiable event responsible for the injury³⁵. Players receive an
34
35 automated link to the online questionnaire sent by email each Sunday, with a reminder email
36
37 the next day to players not responding. Furthermore, if no response is received, a text message
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39 reminder with the link is sent on Tuesdays. Finally, every other week representatives of the
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41 study visit participating football clubs to collect unanswered surveys for the previous two-
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43 week period.
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50 After 52 weeks of participation, a questionnaire with equivalent content as the baseline
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52 questionnaire (excluding OSTRC-O with 2- and 3-6-month recall) are distributed to the
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54 players to evaluate possible changes from the baseline characteristics. The first 106 included
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56 players also underwent a secondary physical test protocol after 52 weeks of follow-up. In the
57
58 one-year follow-up questionnaire, different aspects of UBP and LBP, respectively, in the
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preceding six months are measured. “Have you had UBP/Have you had LBP” (Yes/No)? If yes, has the pain hindered your daily activities (No, Yes to some extent or Yes to a high degree)? If Yes, the “Visual Trajectories Questionnaire – Pain” is used to capture the longitudinal state of a player's pain experience of UBP and LBP and are retrospectively reported for the preceding six-month period⁴⁵. See Table 1 for an overview of the measurements during the different phases of the study.

Table 1. Summary of the included measurements during the different phases of the study.

Phase	Measurements	Tests/tools
Baseline: players (consecutive during inclusion; 2016- ongoing)	Demographic information, general health status (history of pain, illness, medication, plagues, menstrual cycle, back and neck pain), lifestyle (sleep patterns, resilience, food supplements, use of tobacco or alcohol), stress, socioeconomic factors (guardians' education), football related factors (position, years of experience, injury preventive strategies.	KIC Baseline players, The Chronic Pain Questionnaire (CPQ) ⁴⁴ , Visual Trajectories Questionnaire- Pain (VTQ-P) ⁴⁵ ,
	Anthropometric measurements (height, weight, leg length), and measurement of strength, mobility and control of lower extremity, trunk, and neck.	KIC test protocol
	History of injury and complaints	Modified OSTRC-O ^{42 43}
	Passion	Passion scale ⁴⁰
	General Health	GHQ-12 ³⁸
	Coping strategies	Brief COPE ³⁹
Baseline: coaches (consecutive during	Education, years of experience, the use of warmup and stretching regime and implementation of injury prevention programs.	KIC Baseline coaches

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2
3 inclusion; 2016-
4 ongoing)

5 6 7 8 Weekly follow-up: 9 players (September 10 2016-ongoing)	11 Exposure to football training and match play 12 13 Exposure to other physical activity. 14 Health (e.g., stress, recovery) and social 15 support. 16 Report on pain, injury performance complaints.	17 KIC weekly 18 report 19 20 Modified 21 OSTRC-O ^{42 43}
22 23 24 In case of a 25 substantial injury 26 event	27 Report on injury/complaint (type of injury, 28 localisation, inciting event)	29 KIC medical 30 report
31 One-year follow-up: 32 players (consecutive 33 after 52 weeks 34 participation: 2017- 35 ongoing)	36 Football related factors (position, injury 37 preventive strategies). 38 Health status (pain in back or neck) lifestyle 39 (sleep patterns, resilience, food supplements, 40 use of tobacco or alcohol, physical activity), 41 stress, coping and passion for sport.	42 KIC One-year 43 questionnaire
44 One-year follow-up 45 (consecutive after 52 46 weeks participation 47 in the first 106 48 included players)	49 Anthropometric measurements (height, weight, 50 leg length), and measurement of strength, 51 mobility and control of lower extremity, trunk, 52 and neck.	53 KIC test protocol

53 **Sample size**

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56 The statistical power for the analyses will depend on the exact research question, the number
57 of exposed players, and whether the exposure is continuous or categorised. The sample size in
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3 the KIC project is based on the definition “a substantial injury” as proposed by Clarsen et
4 al.,⁴², and back injuries in adolescent female players in a previously published study⁷. Based
5
6 on a relative risk of 1.9 for a substantial injury in the back/neck, when 88 of the players are
7
8 exposed, and with a power of 0.80, a significance level 5 % and with potential 10% drop out
9
10 and a follow-up time of one year to identify risk factors, 420 players will be included.
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14 15 **Statistical methods**

16
17 The data in the KIC study will be used to answer several different research questions and
18
19 therefore, different analyses methods and statistics will be used. Kaplan-Meier estimates will
20
21 be used to describe incidence. Cox regression analyses or discrete time survival analyses will
22
23 be used to measure the associations between exposure and outcome, and to adjust for
24
25 confounding. Only players without substantial injuries the two preceding months (reported in
26
27 the baseline questionnaire) will be considered in the risk analyses, and stratified analyses to
28
29 examine effect measure modification will be performed when relevant. The development of
30
31 injuries is likely complex. This justifies why we measure an extensive number of factors so
32
33 that we can consider confounders, intermediators, and effect measure modifier in these
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35 analyses. When identifying trajectories of time, and various factors Generalized Estimating
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37 Equations will be used for these analyses to consider the covariance between repeated
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39 measurements.
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46 47 **Time plan**

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49 Players will be recruited from 2017 and followed weekly for one year regarding
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51 injuries/complaints. Players will consecutively be invited and included from the year they turn
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53 13 years old and play in a participating club. The inclusion of participants will continue until
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55 we reach over 400 players.
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60 **Data statement**

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3 The dataset and statistical codes will be available on reasonable request when the data
4 collection is completed.
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8 **Patient and public involvement**

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11 No patient involved
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ETHICS AND DISSEMINATION

The study was approved by the Regional Ethical Review Authority at Karolinska Institutet, Stockholm, Sweden (2016/1251-31/4). All participating players and their legal guardians receive written and oral information regarding the study and give their written informed consent when entering the study. Players under the age of 15 are required to have written informed consent from their legal guardians. The study will be performed in accordance with the recommendations guiding research involving human subjects adopted by the 18th World Medical Association General Assembly, Helsinki, Finland, June 1964, amended at the 64th World Medical Association General Assembly, Fortaleza, Brazil, October 2013. The study will be reported in accordance with the Strengthening the Reporting of Observational studies in Epidemiology (STROBE)³³. The results will be presented in scientific conferences and published in peer-reviewed academic journals as well as being disseminated to the Swedish football movement through stakeholders and media.

FOOTNOTES

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Author Contributions VL, ES, MA and UT initiated the study. All authors, UT, NW, VL, MH, MW, UJ, MA, and ES conceived the study and contributed to the development of the study protocol. ES is the study guarantor. UT and NW bi-drafted the manuscript which was critically revised in steps by all co-authors. The final manuscript was approved by all authors.

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REFERENCES

1. Federation Internationale de Football Association F. Women's football survey. 2014. (accessed 2020-11-03).
2. López-Valenciano A, Ruiz-Pérez I, Garcia-Gómez A, et al. Epidemiology of injuries in professional football: a systematic review and meta-analysis. *Br J Sports Med* 2020;54(12):711-18. doi: 10.1136/bjsports-2018-099577 [published Online First: 2019/06/07]
3. Bennett P, Fawcett L. Trauma injuries sustained by female footballers. *Trauma* 2006;8(2):69-76. doi: 10.1177/1460408606072682
4. Häggglund M, Waldén M, Ekstrand J. Injuries among male and female elite football players. *Scand J Med Sci Sports* 2009;19(6):819-27.
5. Faude O, Junge A, Kindermann W, et al. Injuries in female soccer players - A prospective study in the German national league. *Am J Sport Med* 2005;33(11):1694-700. doi: 10.1177/0363546505275011
6. Le Gall F, Carling C, Reilly T. Injuries in young elite female soccer players. *Am J Sport Med* 2008;36(2):276-84. doi: 10.1177/0363546507307866
7. Clausen MB, Zebis MK, Moller M, et al. High Injury Incidence in Adolescent Female Soccer. *Am J Sport Med* 2014;42(10):2487-94. doi: 10.1177/0363546514541224
8. Larruskain J, Lekue JA, Diaz N, et al. A comparison of injuries in elite male and female football players: A five-season prospective study. *Scand J Med Sci Sports* 2018;28(1):237-45. doi: 10.1111/sms.12860
9. Lohmander LS, Ostenberg A, Englund M, et al. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum* 2004;50(10):3145-52. doi: 10.1002/art.20589
10. Prien A, Prinz B, Dvorak J, et al. Health problems in former elite female football players: Prevalence and risk factors. *Scand J Med Sci Sports* 2017;27(11):1404-10. doi: 10.1111/sms.12747
11. Roos EM. Joint injury causes knee osteoarthritis in young adults. *Curr Opin Rheumatol* 2005;17(2):195-200.
12. Wylleman P, Reints A. A lifespan perspective on the career of talented and elite athletes: Perspectives on high-intensity sports. *Scand J Med Sci Sports* 2010;20:88-94. doi: 10.1111/j.1600-0838.2010.01194.x
13. Putukian M. The psychological response to injury in student athletes: a narrative review with a focus on mental health. *Brit J Sport Med* 2016;50(3):145-48. doi: 10.1136/bjsports-2015-095586
14. Van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. *Sports Med* 1992;14(2):82-99.
15. Dvorak J, Junge A, Chomiak J, et al. Risk factor analysis for injuries in football players - Possibilities for a prevention program. *Am J Sport Med* 2000;28(5):S69-S74.
16. Steffen K, Engebretsen L. More data needed on injury risk among young elite athletes. *Brit J Sport Med* 2010;44(7):485-89. doi: 10.1136/bjism.2010.073833
17. Wiese-Bjornstal DM. Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a consensus statement. *Scand J Med Sci Sports* 2010;20(s2):103-11. doi: 10.1111/j.1600-0838.2010.01195.x
18. Häggglund M, Waldén M. Risk factors for acute knee injury in female youth football. *Knee Surg Sport Tr A* 2016;24(3):737-46. doi: 10.1007/s00167-015-3922-z
19. Faude O, Junge A, Kindermann W, et al. Risk factors for injuries in elite female soccer players. *Brit J Sport Med* 2006;40(9):785-90. doi: 10.1136/bjism.2006.027540
20. Steffen K, Pensgaard AM, Bahr R. Self-reported psychological characteristics as risk factors for injuries in female youth football. *Scand J Med Sci Sports* 2009;19(3):442-51. doi: 10.1111/j.1600-0838.2008.00797.x

- 1
- 2
- 3
- 4 21. Alahmad TA, Kearney P, Cahalan R. Injury in elite women's soccer: a systematic review. *Phys Sportsmed* 2020;1-7. doi: 10.1080/00913847.2020.1720548 [published Online First: 2020/02/07]
- 5
- 6 22. Magnusson K, Turkiewicz A, Hughes V, et al. High genetic contribution to anterior cruciate
- 7 ligament rupture: Heritability ~69%. *Br J Sports Med* 2020;55(7):385-89. doi:
- 8 10.1136/bjsports-2020-102392
- 9
- 10 23. Ostenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123
- 11 players during one season. *Scand J Med Sci Sports* 2000;10(5):279-85. doi: 10.1034/j.1600-
- 12 0838.2000.010005279.x
- 13 24. Watson A, Brickson S, Brooks MA, et al. Preseason aerobic fitness predicts in-season injury and
- 14 illness in female youth athletes. *Orthop J Sports Med* 2017;5(9) doi:
- 15 10.1177/2325967117726976
- 16 25. Soderman K, Alfredson H, Pietila T, et al. Risk factors for leg injuries in female soccer players: a
- 17 prospective investigation during one out-door season. *Knee Surg Sport Tr A* 2001;9(5):313-
- 18 21. doi: 10.1007/s001670100228
- 19
- 20 26. Nilstad A, Andersen TE, Bahr R, et al. Risk factors for lower extremity injuries in elite female
- 21 soccer players. *Am J Sport Med* 2014;42(4):940-48. doi: 10.1177/0363546513518741
- 22 27. Blokland D, Thijs KM, Backx FJ, et al. No effect of generalized joint hypermobility on injury risk in
- 23 elite female soccer players: A prospective cohort study. *Am J Sports Med* 2017;45(2):286-93.
- 24 doi: 10.1177/0363546516676051
- 25 28. Feldman DE, Shrier I, Rossignol M, et al. Risk factors for the development of neck and upper limb
- 26 pain in adolescents. *Spine* 2002;27(5):523-28.
- 27 29. Johnson U, Ivarsson A. Psychological predictors of sport injuries among junior soccer players.
- 28 *Scand J Med Sci Sports* 2011;21(1):129-36. doi: 10.1111/j.1600-0838.2009.01057.x
- 29 30. Ivarsson A, Johnson U, Lindwall M, et al. Psychosocial stress as a predictor of injury in elite junior
- 30 soccer: A latent growth curve analysis. *J Sci Med Sport* 2014;17(4):366-70. doi:
- 31 10.1016/j.jsams.2013.10.242
- 32 31. Junge A, Rosch D, Peterson L, et al. Prevention of soccer injuries: A prospective intervention study
- 33 in youth amateur players. *Am J Sport Med* 2002;30(5):652-59.
- 34 32. Pensgaard AM, Ivarsson A, Nilstad A, et al. Psychosocial stress factors, including the relationship
- 35 with the coach, and their influence on acute and overuse injury risk in elite female football
- 36 players. *BMJ Open Sport Exerc Med* 2018;4(1):e000317. doi: 10.1136/bmjsem-2017-000317
- 37 33. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies
- 38 in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. *Int J*
- 39 *Surg* 2014;12(12):1495-99. doi: 10.1016/j.ijvs.2014.07.013
- 40 34. Walden M, Atroshi I, Magnusson H, et al. Prevention of acute knee injuries in adolescent female
- 41 football players: cluster randomised controlled trial. *Bmj-British Medical Journal* 2012;344
- 42 doi: 10.1136/bmj.e3042
- 43 35. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data
- 44 collection procedures in studies of football (soccer) injuries. *Brit J Sport Med* 2006;40(3):193-
- 45 201. doi: 10.1136/bjsm.2005.025270
- 46 36. Hägglund M, Waldén M, Bahr R, et al. Methods for epidemiological study of injuries to
- 47 professional football players: developing the UEFA model. *Brit J Sport Med* 2005;39(6):340-
- 48 46.
- 49 37. Emery CA, Meeuwisse WH, Hartmann SE. Evaluation of risk factors for injury in adolescent soccer:
- 50 implementation and validation of an injury surveillance system. *Am J Sport Med*
- 51 2005;33(12):1882-91.
- 52 38. Hardy GE, Shapiro DA, Haynes CE, et al. Validation of the general health questionnaire-12 using a
- 53 sample of employees from England's health care services. *Psychol Assess* 1999;11(2):159-65.
- 54 doi: 10.1037/1040-3590.11.2.159
- 55 39. Carver CS. You want to measure coping but your protocol's too long: Consider the brief COPE. *Int*
- 56 *J Behav Med* 1997;4(1):92-100. doi: 10.1207/s15327558ijbm0401_6
- 57
- 58
- 59
- 60

- 1
- 2
- 3 40. Vallerand RJ, Blanchard C, Mageau GA, et al. Les passions de l'Ame: On obsessive and harmonious
- 4 passion. *J Pers Soc Psychol* 2003;85(4):756-67. doi: 10.1037/0022-3514-85.4.756
- 5 41. Salminen S, Kouvonen A, Koskinen A, et al. Is a single item stress measure independently
- 6 associated with subsequent severe injury: a prospective cohort study of 16,385 forest
- 7 industry employees. *Bmc Public Health* 2014;14(1):543.
- 8 42. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration
- 9 of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre
- 10 (OSTRC) overuse injury questionnaire. *Br J Sports Med* 2013;47(8):495-502.
- 11 43. Ekman E, Frohm A, Ek P, et al. Swedish translation and validation of a web-based questionnaire
- 12 for registration of overuse problems. *Scand J Med Sci* 2015;25(1):104-9. doi:
- 13 10.1111/sms.12157
- 14 44. Von Korff M, Ormel J, Keefe FJ, et al. Grading the severity of chronic pain. *Pain* 1992;50(2):133-
- 15 49.
- 16 45. Dunn KM, Campbell P, Jordan KP. Validity of the visual trajectories questionnaire for pain. *J Pain*
- 17 2017;18(12):1451-58.
- 18 46. Dennis RJ, Finch CF, Elliott BC, et al. The reliability of musculoskeletal screening tests used in
- 19 cricket. *Phys Ther Sport* 2008;9(1):25-33. doi: 10.1016/j.ptsp.2007.09.004
- 20 47. Youdas JW, Bogard CL, Suman VJ. Reliability of goniometric measurements and visual estimates
- 21 of ankle joint active range of motion obtained in a clinical setting. *Arch Phys Med Rehab*
- 22 1993;74(10):1113-18. doi: 10.1016/0003-9993(93)90071-h
- 23 48. Ness BM, Sudhagani RG, Tao H, et al. The reliability of a novel heel-rise test versus goniometry to
- 24 assess plantarflexion range of motion. *Int J Sports Phys Ther* 2018;13(1):19-27. doi:
- 25 10.26603/ijspt20180019
- 26 49. Konor MM, Morton S, Eckerson JM, et al. Reliability of three measures of ankle dorsiflexion range
- 27 of motion. *Int J Sports Phys Ther* 2012;7(3):279.
- 28 50. Frohm A, Heijne A, Kowalski J, et al. A nine-test screening battery for athletes: a reliability study.
- 29 *Scand J Med Sci* 2012;22(3):306-15. doi: 10.1111/j.1600-0838.2010.01267.x
- 30 51. Asker M, Walden M, Kallberg H, et al. A prospective cohort study identifying risk factors for
- 31 shoulder injuries in adolescent elite handball players: the Karolinska Handball Study (KHASt)
- 32 study protocol. *BMC Musculoskelet Disord* 2017;18 doi: 10.1186/s12891-017-1852-2
- 33 52. Johnson KD, Kim KM, Yu BK, et al. Reliability of thoracic spine rotation range-of-motion
- 34 measurements in healthy adults. *J Athl Training* 2012;47(1):52-60.
- 35 53. Andre MJ, Fry AC, Heyrman MA, et al. A reliable method for assessing rotational power. *J*
- 36 *Strength Cond Res* 2012;26(3):720-24. doi: 10.1519/JSC.0b013e318227664d
- 37 54. Palmer TG, Uhl TL. interday reliability of peak muscular power outputs on an isotonic
- 38 dynamometer and assessment of active trunk control using the chop and lift tests. *J Athl*
- 39 *Training* 2011;46(2):150-59. doi: 10.4085/1062-6050-46.2.150
- 40 55. Zois J, P Sharp A, Talukdar K, et al. The reliability of a rotational power assessment of the core. *J*
- 41 *Athl Enhanc* 2016;5(5)
- 42 56. Arumugam A, Mani R, Raja K. Interrater reliability of the craniocervical flexion test in
- 43 asymptomatic individuals- A cross-sectional study. *J Manipulative Physiol Ther*
- 44 2011;34(4):247-53. doi: 10.1016/j.jmpt.2011.04.011
- 45 57. James G, Doe T. The craniocervical flexion test: intra-tester reliability in asymptomatic subjects.
- 46 *Physiother Res Int* 2010;15(3):144-49.
- 47 58. Thorborg K, Bandholm T, Holmich P. Hip- and knee-strength assessments using a hand-held
- 48 dynamometer with external belt-fixation are inter-tester reliable. *Knee Surg Sport Tr A*
- 49 2013;21(3):550-55. doi: 10.1007/s00167-012-2115-2
- 50 59. Kelln BM, McKeon PO, Gontkof LM, et al. Hand-held dynamometry: Reliability of lower extremity
- 51 muscle testing in healthy, physically active, young adults. *J Sport Rehabil* 2008;17(2):160-70.
- 52 doi: 10.1123/jsr.17.2.160
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

- 1
2
3 60. Prather H, Harris-Hayes M, Hunt DM, et al. Reliability and agreement of hip range of motion and
4 provocative physical examination tests in asymptomatic volunteers. *PM R* 2010;2(10):888-95.
5 doi: 10.1016/j.pmrj.2010.05.005
6
7 61. Nussbaumer S, Leunig M, Glatthorn JF, et al. Validity and test-retest reliability of manual
8 goniometers for measuring passive hip range of motion in femoroacetabular impingement
9 patients. *BMC Musculoskelet Disord* 2010;11 doi: 10.1186/1471-2474-11-194
10
11 62. Sharma N, Sharma A, Sandhu JS. Functional performance testing in athletes with functional ankle
12 instability. *Asian J Sports Med* 2011;2(4):249.
13
14 63. Caffrey E, Docherty CL, Schrader J, et al. The ability of 4 single-limb hopping tests to detect
15 functional performance deficits in individuals with functional ankle instability. *J Orthop Sports*
16 *Phys Ther* 2009;39(11):799-806. doi: 10.2519/jospt.2009.3042
17
18 64. Vaseenon T, Gao Y, Phisitkul P. Comparison of two manual tests for ankle laxity due to rupture of
19 the lateral ankle ligaments. *Iowa Orthop J* 2012;32:9-16.
20
21 65. de Vries JS, Kerkhoffs G, Blankevoort L, et al. Clinical evaluation of a dynamic test for lateral ankle
22 ligament laxity. *Knee Surg Sport Tr A* 2010;18(5):628-33. doi: 10.1007/s00167-009-0978-7
23
24 66. Smith TO, Clark A, Neda S, et al. The intra- and inter-observer reliability of the physical
25 examination methods used to assess patients with patellofemoral joint instability. *Knee*
26 2012;19(4):404-10. doi: 10.1016/j.knee.2011.06.002
27
28 67. Moreau CE, Green BN, Johnson CD, et al. Isometric back extension endurance tests: A review of
29 the literature. *J Manipulative Physiol Ther* 2001;24(2):110-22. doi:
30 10.1067/mmt.2001.112563
31
32 68. Demoulin C, Vanderthommen M, Duysens C, et al. Spinal muscle evaluation using the Sorensen
33 test: a critical appraisal of the literature. *Joint Bone Spine* 2006;73(1):43-50. doi:
34 10.1016/j.jbspin.2004.08.002
35
36 69. Latimer J, Maher CG, Refshauge K, et al. The reliability and validity of the Biering-Sorensen test in
37 asymptomatic subjects and subjects reporting current or previous nonspecific low back pain.
38 *Spine* 1999;24(20):2085-89. doi: 10.1097/00007632-199910150-00004
39
40 70. Malone S, Owen A, Newton M, et al. The acute:chronic workload ratio in relation to injury risk in
41 professional soccer. *J Sci Med Sport* 2017;20(6):561-65. doi: 10.1016/j.jsams.2016.10.014
42
43 71. Nilstad A, Bahr R, Andersen TE. Text messaging as a new method for injury registration in sports:
44 A methodological study in elite female football. *Scand J Med Sci Sports* 2014;24(1):243-49.
45 doi: 10.1111/j.1600-0838.2012.01471.x
46
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This is a supplementary document describing the included tests in Karolinska football Injury Cohort, KIC. Table S1 shows the test stations, number of test leaders and randomization of the tests. The persons in the images have given their consent that the images will be used in publications related to this study.

Calf heel raises

Ankle plantarflexion (PF) muscle endurance is investigated using unilateral barefoot weight bearing calf heel raises⁴⁶. Firstly, the player's maximal weight bearing PF range of motion (ROM) is obtained by painting a reference mark on the player's heel at floor level and registering the maximal height achieved during one calf heel raise with a metric ruler.

The player is thereafter instructed to perform repeated maximum unilateral heel raises until failure, guided by a metronome to standardize the pace (1 second concentric-, 1 second eccentric contraction). The player is allowed to have light contact with her fingers against a wall. A repetition is considered approved on the basis whether knee extension is maintained, and the reference mark on the player's heel levels with the registered maximal PF ROM height on the ruler. The test leader registers the total number of approved repetitions and discontinues the test when the player fails to reach the marked maximal height. The same procedure is then conducted on the opposite foot. The order of execution is randomized prior to the test.



Figure S1. Calf heel raises.

Active plantarflexion mobility

Active PF ROM is measured with a clear plastic goniometer positioned at the lateral malleolus, utilizing fibula and fifth metatarsal as reference marks^{47 48}. The player is positioned in supine on an treatment table, with feet off the edge of the table. The player is instructed to perform a sequence of six maximal active PF cycles starting from a neutral dorsiflexion (DF) position, whilst maintaining extended knees throughout the movement. The test leader measures and registers the maximal PF ROM in the final three cycles.

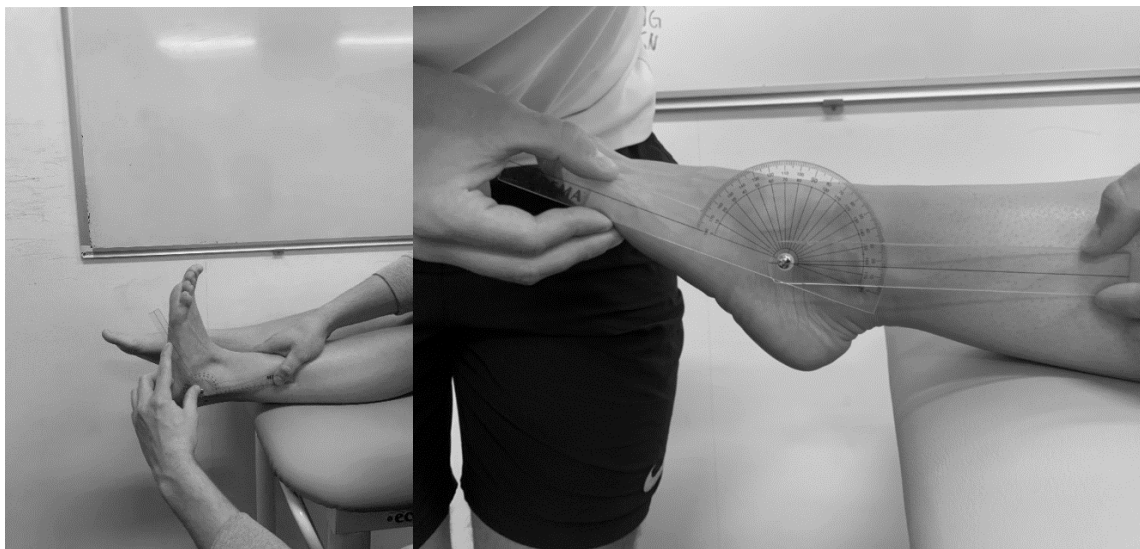


Figure S2. Active plantarflexion mobility execution. a) starting position in neutral dorsiflexion, b) end position in maximal active plantarflexion.

Weight bearing ankle dorsiflexion mobility

Weight bearing ankle DF ROM is measured in a standing lunge position with the player's foot placed upon a metric ruler 10 cm away from a wall to the player's greater toe^{46 49}. The player is instructed to lunge forward, directing the knee in line with her second toe, until contact with the wall is achieved; without allowing the heel to lift off the ground, which is continuously monitored through the availability to maintain a piece of paper against the foundation. Throughout the test, the player is allowed to provide balance by light contact with her fingers against the wall.

Firstly, three consecutive warm-up trials are performed from the 10 cm mark to familiarize the player with the test. Thereafter, the test leader measures the following three trials. In each trial, the player begins from the reference mark (10 cm) and progresses 1 cm away from the wall at a time, until unable to perform a successful repetition. If the player is unable to perform an approved repetition at the 10 cm reference mark, she is asked to progress 1 cm forward until able to complete a successful repetition. Once the player achieves knee-wall contact, the DF ROM is measured with a digital inclinometer (Clinometer, Plaincode, Stephanskirchen, Germany) and the distance from the wall to the greater toe is measured in cm in the repetition furthest away from the wall in each trial.



Figure S3. Weight bearing ankle dorsiflexion mobility.

Trunk mobility

Mobility in trunk rotation are measured in a cross-legged seated position, and in a lunge position with the player on a gym mat, graded with 5 degrees increments, from zero to one hundred and eighty degrees⁵⁰⁻⁵².

In the seated test (modified seated rotation test), the player is positioned at the center of the gym mat, in a cross-legged position with a wooden stick resting on the shoulders whilst keeping her arms crossed. If the player is unable to achieve the cross-legged sitting position, she is allowed to sit comfortable in an ordinary sitting position, which is noted by the test leader. Once in the starting position, the player is instructed to keep an upright posture and maximally rotate alternating between right and left for three times, whilst the test leader measures the rotational degrees in the end range.

The same procedure is thereafter repeated in a lunge position with the wooden stick resting on the player's shoulders. The player is positioned in a lunge position with her posterior knee at the center of the gym mat, and with her feet aligned on the zero-degree mark. Three consecutive maximal rotations are carried out alternating between right and left and is conducted in a lunge position for both the dominant, and non-dominant limb.

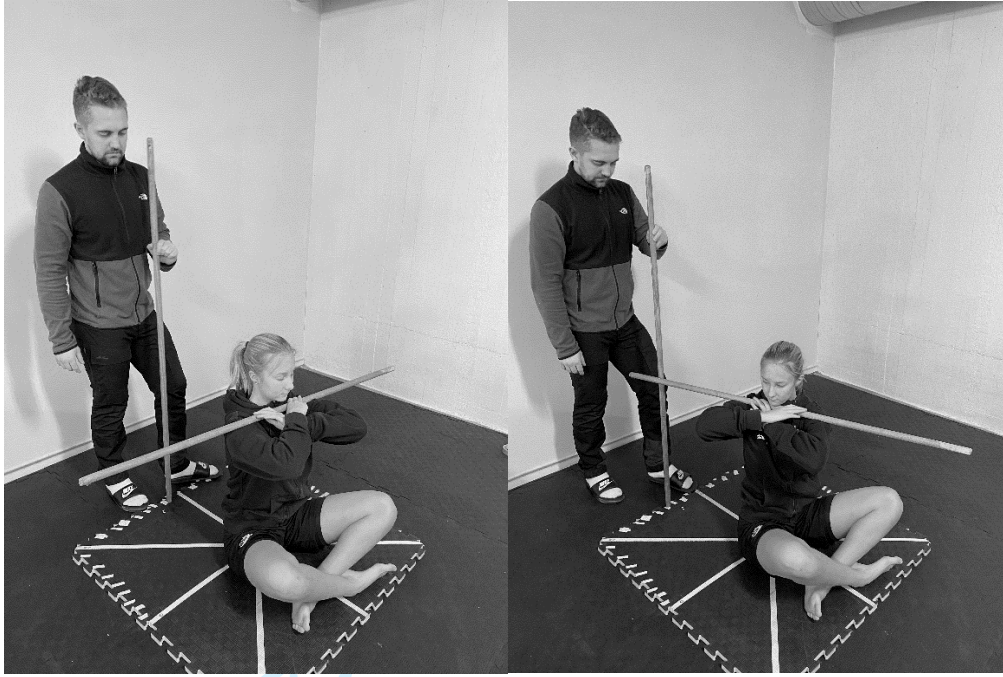


Figure S4. Modified seated rotation test. a) starting position, b) end position (right).

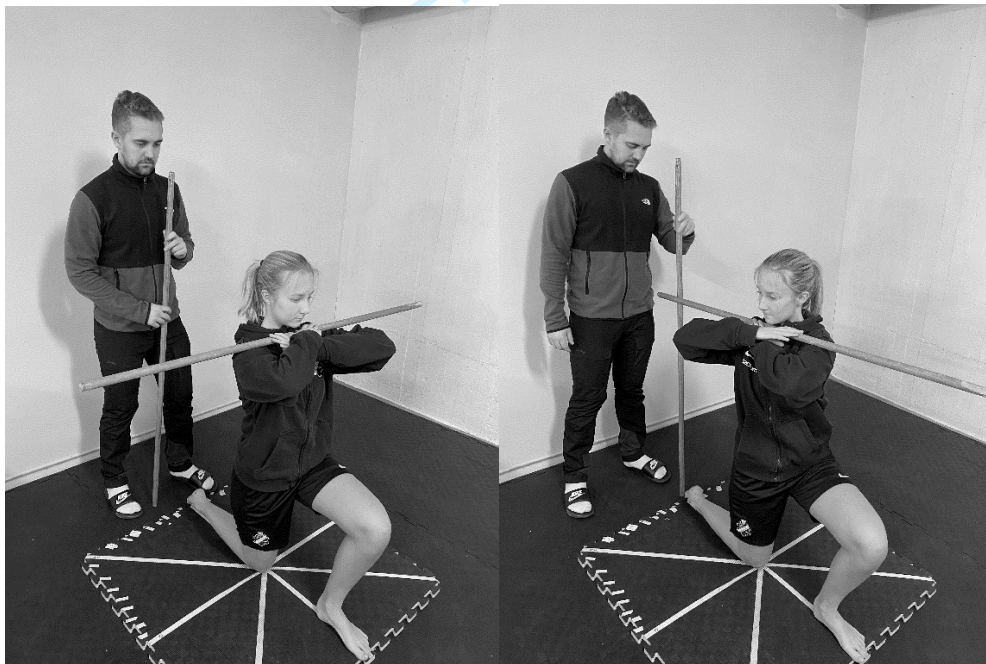


Figure S5. lunge rotation test. a) starting position left leg, b) end position (right).

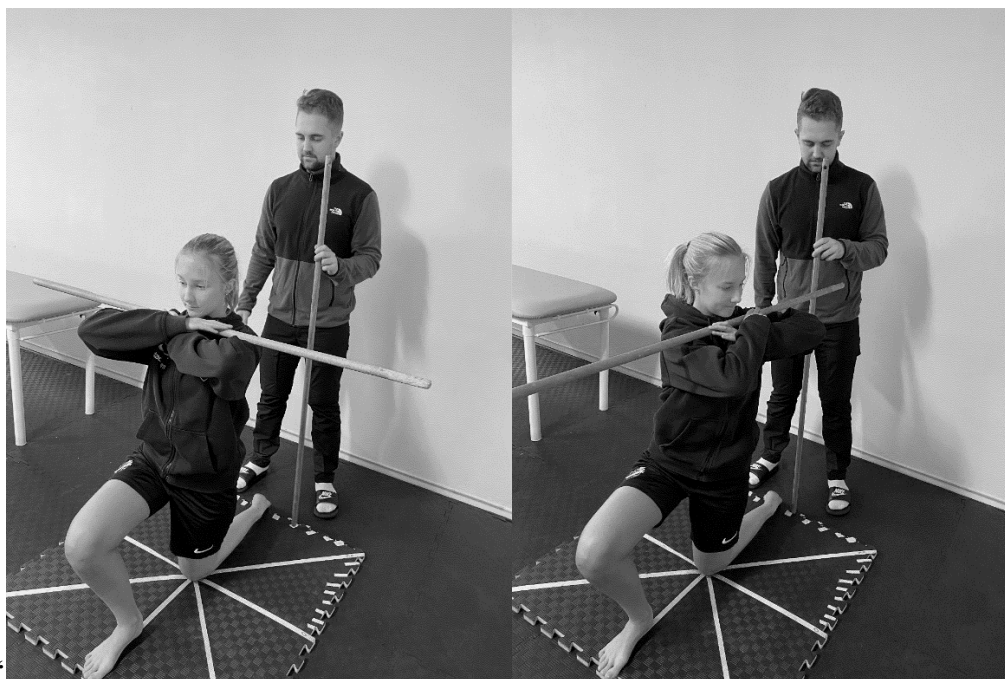


Figure S6. lunge rotation test. a) starting position right leg, b) end position (left).

Trunk strength

Isometric trunk rotational strength is measured in a modified standing wood chopper test utilizing a force gauge to evaluate force output (RS Pro Digital Force Gauge, RS Components Ltd., Corby, UK)⁵³⁻⁵⁵.

In a standing position with extended arms, the player holds a handle in shoulder height, which is attached to the force gauge. The test leader positions the player in a 30-degree trunk rotation in the horizontal plane towards the anchor point (see figure S7).

The player is thereafter instructed to maximally generate force through her trunk and isometrically rotate in the opposite direction for five seconds whilst maintaining straight arms. Three consecutive repetitions are conducted for both right and left, and the maximal force output generated is used in the analyses. The order of execution is randomized prior to performing the test.



Figure S7. Modified standing wood chopper test (isometric rotation to the right).

Deep neck flexor endurance

Deep neck flexor muscle endurance is assessed through a modified version of the Cranio-cervical flexion test (CCFT) with a pressure sensor (Stabilizer Pressure Bio-Feedback, Chattanooga Group inc, Hixon, TN)^{51 56 57}.

Prior to executing the test, the player is instructed in how to perform a correct cranio-cervical flexion motion in standing and supine position through a gentle 'head nodding' cue. The player is positioned in supine position on a treatment table with her hands placed upon her abdomen or at the side of the body and with her feet on the table, with flexed hips and knees. With the player's head and neck in a neutral position, the pressure stabilizer is positioned sub-occipitally, and inflated to a baseline pressure of 20 mmHg. Firstly, a pre-test is conducted and later an endurance test.

During the pre-test, the player is instructed to perform a gentle cranio-cervical flexion to increase the pressure starting from a baseline of 20 mmHg with 2 mmHg increments to a maximum of 30 mmHg. 3x3 second contractions are carried out at each target pressure (TP) with a three second rest in between each contraction whilst the test leader monitors for potential compensational strategies: excessive use of global neck musculature, chin jerking, cervical spine retraction, jaw clenching, breath holding and a pressure loss of ≥ 2 mmHg. A stopwatch time the contractions and visual feedback of pressure level is provided by the test leader who holds the manometer dial so that both the player and the test leader can read it throughout the procedure.

The endurance test is conducted if the player completes each of the five TP (22, 24, 26, 28 and 30 mmHg) without exhibiting any of the compensational strategies and/or experiencing pain during the pre-test. During the endurance test, the same setup and procedure as in the

pre-test is carried out. The player is now instructed to hold each contraction at the TP for 3x10 seconds with a ten second rest in between contractions. The highest completed TP with a full set of 3x10 seconds contractions is registered by the test leader and later used for analysis.



Figure S8. Modified cranio-cervical flexion test.

Hip- and knee strength

Isometric hip flexion, extension, adduction, and abduction strength as well as eccentric hip abduction and adduction and isometric knee extension strength are measured with a hand-held dynamometer (HHD) (MicroFet2, Hoggan Health Industries inc. West Jordan, UT, USA)^{58 59}.

Prior to executing the strength tests, two submaximal isometric contractions in each direction are performed to familiarize the player with the procedures. Three isometric contractions with gradually increasing force output for five seconds, and three maximal eccentric contractions for three seconds are performed in the isometric and eccentric tests, respectively, with a 10 second rest in between each contraction. The maximal force output for each position is registered by the test leader and later used for analysis. The order of execution and starting side is randomized prior to performing the tests at the particular test station (see table S1).

Isometric hip flexion strength

The player is positioned in a seated position at the edge of an treatment table, with 90-degrees of hip- and knee flexion. The HHD is positioned two centimeters proximal to the patella, and are externally fixated with a belt, which is secured under the leg of the treatment table, limiting hip flexion movement. The player is instructed to perform three isometric contractions on each leg.

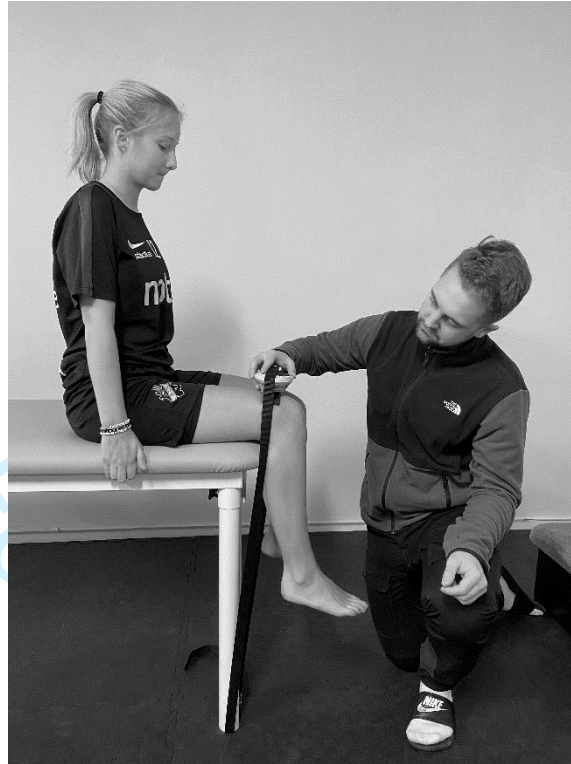


Figure S9. Isometric hip flexion strength (right hip).

Isometric knee extension strength

Seated in the same position as during the isometric hip flexion strength test, with a slightly extended knee joint, the HHD is positioned two centimeters proximal to the malleoli on the anterior aspects of the player's tibia and are externally fixated with a belt. The player is instructed to perform three isometric contractions on each leg respectively.

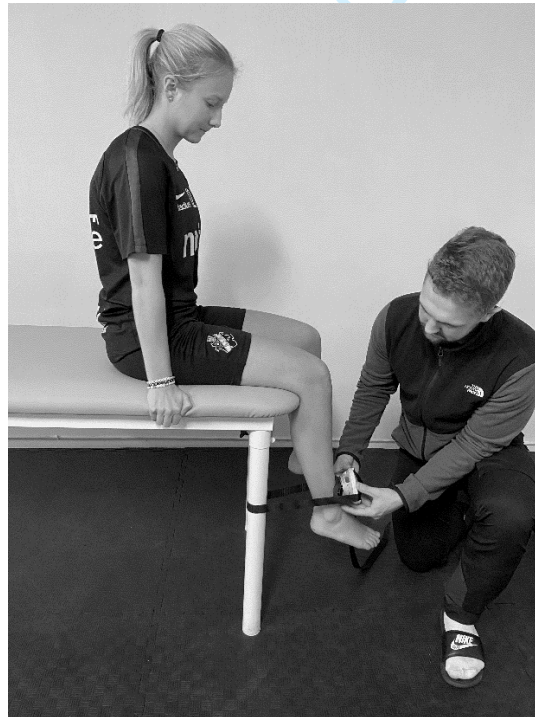


Figure S10. Isometric knee extension strength (right leg).

Isometric hip extension strength

With the player positioned in a prone position on a treatment table and with her feet off the edge of the table, the test leader externally fixates the HHD two centimeters proximal to the malleoli with a belt. Furthermore, the player is instructed to perform three maximal isometric contractions on each leg respectively



Figure S11. Isometric hip extension strength (left hip).

Isometric hip abduction strength

The player is positioned in a supine position on an treatment table, with the tested leg extended, and the non-tested leg flexed. The test leader positions and fixates the HHD two centimeters proximal to the lateral malleolus with a belt, which limits hip abduction movement. Thereafter, the player is instructed to perform three maximal isometric hip abductions, whilst the test leader measures the force output for both the left, and right side.



Figure S12. Isometric hip abduction strength (left hip).

Isometric hip adduction

Lying in the same position as during the isometric hip abduction the test leader places and fixates the HHD two centimeters proximal to the medial malleolus with a belt. Consequently, the player executes three maximal isometric hip adductions on the left and right side, whilst the test leader registers the force output.



Figure S13. Isometric hip adduction strength (right hip).

Eccentric hip abduction strength

The player is in a side-lying position on an treatment table with the test leg extended, and the opposite leg flexed to 90 degrees in the knee- and hip joint, whilst a neutral hip position is maintained. The player is subsequently instructed to place the test leg in approximately 40 degrees of hip abduction, and the test leader places a HHD one centimeter proximally to the lateral malleolus. The test leader initiates the test by saying “push”, and when the player has built up a maximal isometric contraction, the test leader begins to apply a downward directed force with the HHD whilst the player resists eccentrically for five seconds. Three repetitions are carried out on both the right and leg left, and the maximal force output is later used for analysis.



Figure S14. Eccentric hip abduction strength. a) starting position (right hip), b) end position (right hip).

Eccentric hip adduction strength

The player is positioned in the same manner as in the eccentric hip abduction strength test, with the tested leg extended, and the non-tested leg flexed in the hip- and knee joint. Thereafter, the player is instructed to place the test leg in a maximal adduction position, whereupon the test leader positions a HHD one centimeter proximally to the medial malleolus. The test is initiated when the test leaders says “push”, whereupon a downward directed force is applied with the HHD whilst the player resists eccentrically for five seconds. Three consecutive trials are conducted on both sides, and the test leader registers the force output.



Figure S15. Eccentric hip abduction strength. a) starting position (left hip), b) end position (left hip).

Hip mobility

Measures of passive hip ROM in flexion, extension, abduction, internal- and external rotation are obtained using a universal clear plastic goniometer^{60 61}. Three consecutive measurements for each position are performed for both the dominant and the non-dominant leg and the mean value for each position is later used for analysis. If the same value is obtained during the first and second measurement for a particular movement, a third one is not performed. The order of execution (side and movement) is randomized prior to performing the measures.

Passive hip flexion ROM

The player is positioned in supine position on a treatment table. With the player's leg held in a 90-degree knee flexion, test leader 1 moves the player's leg into a passive hip flexion until a firm end feel is achieved, and a posterior pelvic tilt occurs. Once the end feel is achieved, test leader 2 places the center of the goniometer at the greater trochanter and aligns one of the goniometer's arms with the player's femur, and the other one horizontally with the treatment table to read the goniometer. Three consecutive measures are conducted on each hip.



Figure S16. Passive hip flexion ROM (left hip).

Passive hip abduction ROM

The player is in a supine position on an treatment table with extended legs. While palpating the player's ipsilateral anterior superior iliac spine, test leader 1 holds the player's leg by the ankle and moves the leg into passive hip abduction until a firm end feel is achieved, and motion is felt at the pelvis. Thereafter, test leader 2 positions the goniometer at the player's hip, aligning the lever arms with the player's anterior superior iliac spine and femur, and reads the degrees of abduction. The test is repeated three times on each hip.



Figure S17. Passive hip abduction ROM (left hip).

Passive hip extension ROM

In prone position with extended legs, test leader 1 fixates the player's pelvis by placing a hand at the ipsilateral posterior superior iliac spine. Thereafter, while holding the player's leg at the knee, test leader 1 moves the player's leg into passive hip extension, until an end feel is achieved, indicated by an anterior tilt of the pelvis. Test leader 2 measures the degrees of passive hip flexion with the goniometer's center positioned at the greater trochanter, and the lever arms in line with the player's femur and the treatment table horizontally. Three measures are performed on each leg.



Figure S18. Passive hip extension ROM (right hip).

Passive hip internal- and external rotation ROM

In prone position, the player's leg is flexed to 90 degrees in the knee joint. Consequently, test leader 1 fixates the pelvis by placing his/her hand on the player's posterior superior iliac spine and performs a passive internal and external hip rotation, respectively, until an end feel is felt, indicated by an anterior pelvic tilt. Test leader 2 measures the degree of rotational mobility with a goniometer positioned at the knee, with the levers aligned with the player's tibia and with the treatment table horizontally. Three consecutive measures are conducted on each leg.



Figure S19. Passive hip rotational ROM (right hip). a) internal rotation, b) external rotation.

Jump performance tests

To assess the player's unilateral jump performance, the One-leg Long Box Jump Test (OLLBJ) and square hop test are performed^{62 63}. A 40x40 cm square is marked on the foundation and later utilized as a reference mark in both tests. During the jump tests, players wear indoor sporting shoes.

One-leg long box jump test (OLLBJ)

Firstly, the starting position, i.e. the distance player's jump from to the 40x40 cm square is calculated by dividing the player's height in cm with 1.6 (height/1.6 = distance to the square). The player is instructed to stand on one leg at the starting position, and to perform a one-legged jump aiming inside the boundaries of the 40x40 cm square, and to maintain balance after landing. A trial is considered approved on the basis that the player land inside the 40x40 cm square, and adequately maintains balance after landing. The player performs three warm up trials on each leg, to familiarize with the procedure, and later five consecutive test trials. The test leader registers the total number of approved trials on each leg (0 to 5).



Figure S20. One-leg long box jump test (right leg). a) starting position, b) landing, c) balance maintained.

Square hop test

During the square hop test, the player is instructed to hop on one leg in and out of the 40x40 cm square as many times as possible for 15 seconds in a clockwise direction, timed with a stopwatch, whilst the test leader registers the number of approved hops. A hop is classified as approved on the basis whether the player begins a hop in the starting position (outside the square) and then executes the short hop task inside the square and then in the correct direction outside the square. Prior to the test, the player performs two warm up trials on each foot.

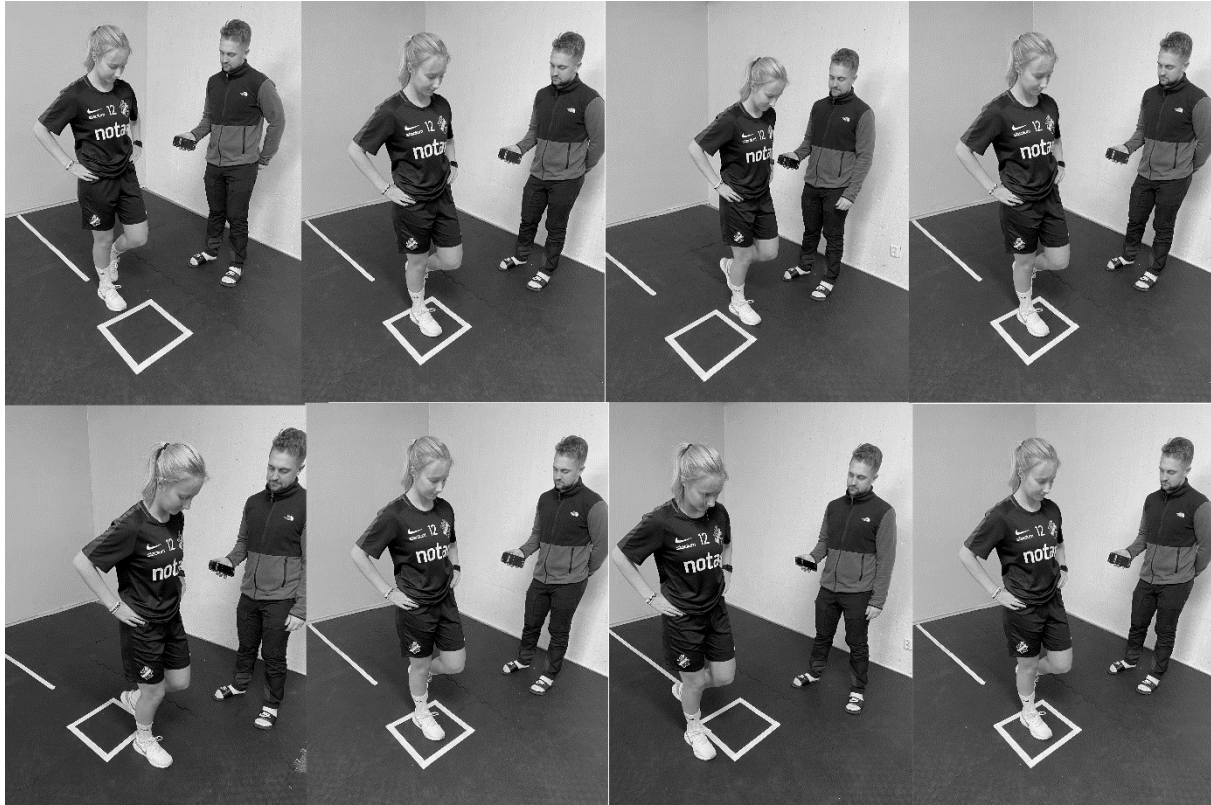


Figure S21. A series of square hop tests illustrated on the player's right leg.

Ankle- & knee stability

Modified anterior drawer test (ankle)

To assess talocrural stability or pain, a modified anterior drawer test is performed^{64 65}. With the player in supine position with the test limb in knee flexion and the on the treatment table, the test leader applies an anteriorly directed force to the player's talus and a concurrent posteriorly directed force to the calcaneus. The test is conducted once on both the dominant and non-dominant foot and are considered positive if the player experiences any pain or discomfort during the procedure.



Figure S22. Modified anterior drawer test (right ankle).

Modified Fairbank's apprehension test (patellofemoral)

A modified version of Fairbank's apprehension test is conducted to evaluate stability or pain in the patellofemoral joint⁶⁶. In supine position with extended legs, the test leader applies a laterally and subsequently medially directed force to the patella. The test is considered positive if the player experiences any pain or discomfort during the test, and/or an involuntary contraction of the quadriceps musculature. The test is carried out once on the player's dominant and non-dominant limb.



Figure S23. Modified Fairbank's apprehension test (left patellofemoral joint).
a) lateral translation, b) medial translation.

Isometric back extensor endurance

Isometric back extensor endurance is assessed by a modified Sorensen test⁶⁷⁻⁶⁹. In prone position, the player's anterior superior iliac spine is positioned at the edge of the treatment table. The player's lower body is supported to the treatment table with three straps positioned over the player's ankles, knees, and pelvis. Whilst the test leader fastens the player's lower body to the treatment table with the three straps, the player uses a box/stool for support.

The player is thereafter instructed to keep her arms folded across the chest and isometrically maintain the upper body in a horizontal position until failure whilst the test leader register the time elapsed. A digital inclinometer (Clinometer, Plaincode, Stephanskirchen, Germany) is placed upon a metric ruler at the level of the 5th vertebra of the thoracical spine to monitor sagittal plane movement. If the player's upper body deviate greater than 10 degrees in the sagittal plane on more than two occasions and/or experience pain during the procedure, the test is stopped. Prior to the test, the player completes a shorter warmup trial of 5 seconds to orient the desired sagittal plane target angle.



Figure S24. Modified Sorensen test.

Table S1. Test stations, number of test leaders and randomization of the physical test protocol.

Test	Test station	Number of test leaders	Randomized order of execution
Calf heel raises	1	1	Yes
Active plantarflexion mobility	2	1	No
Weight bearing ankle dorsiflexion mobility	2	1	No
Ankle- & Knee stability	2	1	No
Hip mobility	3	2	Yes
Isometric Knee extension, hip flexion & extension strength	4	2	Yes
Trunk mobility	5	1	No
Trunk strength	5	1	Yes
Isometric and eccentric hip abduction and adduction	6	2	Yes
Deep neck flexor endurance	7	1	n/a
Functional performance tests	8	1	Yes
Isometric back extensor endurance	9	1	n/a

n/a-not applicable