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Identifying current uses of return to work screening tests and their effectiveness of reducing the risk of reinjury in athletic occupations – A systematic review

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A B S T R A C T

Objective: To identify the current return-to-work (RTW) screening tests conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk.
Methods: A search was made of multiple databases (BioMed Central, CINAHL through ebscohost, EMBASE, Google Scholar, PUBMED, Scopus, SPORTDiscus and Web of Science) from their inception to March 2022, using relevant terms to identify articles meeting predefined inclusion/exclusion criteria. The search, data extraction, risk of bias, and evaluation of the certainty of the findings were completed independently by two authors. To understand the effectiveness of screening tests and their impact in reducing in reinjury rates, results were split into the following three time points: "Short-term" (≤1 year), "Medium-term" (≥2 years) and "Long-term" (≥3 years).
Results: Five studies ($n = 507$) met the inclusion criteria. There was a very low level of certainty for the effectiveness of screening tools reducing reinjury risk at short-term, medium-term and long-term follow ups. Only one study recorded a large effect in the reducing reinjury risk.
Conclusion: The results demonstrated very low level of certainty for the effectiveness of screening tests reducing the risk of reinjury. A gap in our understanding currently exists for the effectiveness of RTW screening tests in tactical athletic occupations following injury and further research investigating is required.

1. Introduction

Physical screening tests are a tool to help identify those at an increased risk of disease or disorder (Grimes & Schulz, 2002). Such tests can be used to identify individuals at high risk of developing a musculoskeletal injury (Dallinga et al., 2012) and can involve the assessment of performance factors including balance, muscular strength and range of motion (Stokes et al., 2020). The results from these tests can help determine an individual's readiness to return to work (RTW) following an injury or period of absence (Pikaar, 2012).

Individuals with an athletic occupation, are required to possess certain levels of muscular strength and aerobic fitness to reduce injury risk and perform optimally (García-Pallarés & Izquierdo, 2011; Zouita et al., 2016). Although fitness level criteria may vary between different occupations, it is important that individuals with an athletic occupation are able to reach these standards before returning to work (Ardern et al., 2016; Scofield & Kardouni, 2015). Individuals with athletic occupations can be categorised as professional athletes and tactical athletes. Tactical athletes are individuals working in firefighting, police, paramedic, and military occupations (Scofield & Kardouni, 2015). Again, although fitness level criteria may vary between different occupations, it is important that the tactical athlete is able to reach these standards required before returning to work (Ardern et al., 2016; Scofield & Kardouni, 2015).

A successful RTW following injury in athletic occupations can be defined as when an individual is able to complete all work task demands safely and independently, reaching at least the baseline level of fitness required for their role (Pikaar, 2012). Methods for assessing RTW can be expensive, are often time consuming and

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equipment required can be difficult to transport, creating a potential barrier for their use (Chimera & Warren, 2016; Plisky et al., 2006). To help remove these barriers, screening tests have been created to be more user friendly by being easy to administer, using minimal equipment which is portable (Chimera & Warren, 2016; Plisky et al., 2006). This ease of use for screening tests has resulted in a rise in their popularity as a method to reduce injury risk (Chimera & Warren, 2016; Plisky et al., 2006). Results from a RTW screening test provide data that can help to identify if an individual's present performance is equal to or above their occupational demands (Hart et al., 1993; Isernhagen, 1992). These data are useful to assist in determining suitable recommendations for an individual's RTW, including what tasks are deemed safe to perform, running and lifting and tasks to avoid or perform in a modified manner and running with change of direction or overhead lifting, which could help in reducing the risk of reinjury (Hart et al., 1993; Isernhagen, 1992).

Previous research has identified that injury risk categorisation is population-specific to the required occupational demands (Hewett et al., 2005; Zazulak et al., 2007). Athletic occupations require muscular strength and aerobic fitness to complete job-related tasks (Lovitz, 2019; Nabe-Nielsen et al., 2021). These demands can involve challenging working conditions including lifting heavy loads on a regular basis or continuous repetitive work with lighter loads over a prolonged period of time (Lovitz, 2019; Smith & Mustard, 2004).

Current screening tests including the Functional Movement Screen (FMS) are used in athletic occupations assess injury risk for individuals who are fit and healthy with no prior injury (Agresta et al., 2014; Chorba et al., 2010; Frost et al., 2017; Shojaedin et al., 2014). The main purpose of the FMS is to predict injury risk from identify movement deficits and asymmetries (Teyhen et al., 2012). However, there is limited research on screening tests used for a RTW decision following injury and the risk of reinjury in athletic occupations (Houghton et al., 2016; Noll et al., 2021; Tol et al., 2014). In addition, reinjury following a RTW could cause further economic implications for the workplace including increased sick pay costs and potential increased workload for other members of staff (Black et al., 2018). Updated guidance for the use of best screening tools to reduce injury risk is consequently needed.

Therefore, the aim of this systematic review was to identify the current return-to-work (RTW) screening tests conducted for athletic occupations following injury and their effectiveness of reducing reinjury risk.

2. Methods

This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) (Appendix 1). This study was prospectively registered and published with PROSPERO (ID:CRD42021260947).

2.1. Data sources and search strategy

An electronic search of BioMed Central, CINAHL through ebscohost, EMBASE, Google Scholar, PUBMED, Scopus, SPORTDiscus and Web of Science was undertaken from their inception to March 2022 (Table 1). Two review authors (L.N. and K.M.) independently screened studies, firstly by title and abstract, and then by full text for eligibility. Disagreements between reviewers were resolved by discussion and if required, by mediation from a third reviewer (A.M. or J.M).

2.2. Eligibility criteria

2.2.1. Population

All included studies contained patients over the age of 18 who were returning to an athletic occupation. There was no restriction on a participant's gender. Any studies including participants who were not involved in an athletic occupation were excluded. There was no restriction on the duration participants had been working in an athletic occupation, length of time since participants' injury or surgery and the use of the screening test and follow up time to assess any reinjury.

2.2.2. Outcome measures

Reinjury Rates after return to work was the primary outcome. Studies not assessing reinjury rates were excluded. Reinjury was defined as an injury of the same type and in the same location on the body (Hägglund et al., 2007). Secondary outcome measures included the nature of the reported injuries, duration away from sport/work and whether participants return to sport participation or full duties.

2.2.3. Study design

Studies were eligible for inclusion if they were, randomised controlled trials (RCTs), non-randomised controlled trials (non-RCTs), cohort studies, case-control studies, case series studies or case studies investigating the effectiveness of screening tests for reducing reinjury rates. Cross sectional studies, reviews and editorials were not included.

2.2.4. Language

Only studies published in English were included.

2.2.5. Risk of bias assessment

The Newcastle Ottawa Scale (NOS) was used by two reviewers (LN & KM) to assess the risk of bias for cohort studies (Stang, 2010). The NOS consists of categories including selection, comparability and outcome or exposure depending on the study type (cohort or case-control series). A star system is used, ranging between zero and nine stars (Stang, 2010) Thresholds set based on overall score; seven to nine stars was considered “Low risk of bias”, four to six stars was considered “Unclear risk of bias” and three or less stars was considered “High risk of bias” (Gates et al., 2018).

2.2.6. Data extraction

Two reviewers (LN & KM) extracted the data using a predetermined extraction form. If there was disagreement, a third reviewer (either AM or JM) resolved the disagreement. Data to be extracted included re-injury rates, time to return to work/sport, return to work/sport rates, types of screening tests utilised.

2.2.7. Data synthesis

To understand the effectiveness of screening tests and their impact in reducing in reinjury rates, results were split into the following three time points based on previous literature (de Waard et al., 2017; Delgado-Noguera et al., 2015): “Short-term” (≤1 year), “Medium-term” (≥2 years) and “Long-term” (≥3 years). Within-group effect sizes were reported for each study and each of the time points of interest. Effect size was interpreted as “Small” (<0.5), “Medium” (0.5–0.7), “Large” (0.8–1.2) or “Very Large” (>1.3) (Sullivan & Feinn, 2012). If effect size was not reported it was calculated manually using Cohen's *d* and magnitude of effect size (Chen et al., 2010).

2.2.8. Assessment of the certainty of the body of evidence of findings

The certainty of the body of evidence of findings was assessed

Table 1
Search terms used for database searches.

Search Term
"Firef*" OR "Firefighters" OR "Injured Firefighter" OR "Athlete" OR "Athletes" OR "Tactical Athlete" OR "Tactical Athlete" OR "Injured Tactical Athlete" OR "Injured Athlete" OR "Athletic" OR "Sportsm?n" OR "Sportswom?n" OR "Sportsperson" OR "Individual" OR "Individuals" OR "Injured Individual" OR "Emergency service" OR "Emergency services" OR "Army" OR "Armed Forces" OR "Military"
AND
"Return to duty" OR "Return to play" OR "Return to sport" OR "Return to compe*" OR "Return from injur*" OR "Return to work" OR "Return to physical activity" OR "Suitable return to work" OR "Back to dut*" OR "Back to play" OR "Back to sport" OR "Back to comp*" OR "Back to work" OR "Injury Rehabilitation" OR "Injury Recovery" OR "Musculoskeletal Rehabilitation" OR "Musculoskeletal Recovery" OR "Musculoskeletal Injury" OR "Musculoskeletal disorder" OR "Low back pain" OR "Back pain" OR "Sciatica" OR "Back ache" OR "Back pain" OR "Lumbar Pain OR "Shoulder injury" OR "Shoulder pain" OR "Physi* treatment" OR "Physiotherapy rehabilitation" OR "Physiotherapy recovery" OR "Occupational therapy" OR "Rehabilitation system" OR "Activity limitation" OR "Participation restriction" OR "Expectations" OR "Work capacity" OR "Work exposure" OR "Work related" OR "Job" OR "Employee" OR "Occupation" OR "Reintegration" OR "Work status"
AND
"Climbing stairs" OR "Stair climbing" OR "Climbing ladder" OR "Ladder climbing" OR "Standing" OR "Repetitive movements" OR "Working above shoulder" OR "Working with bend back" OR "Squatting" OR "Kneeling" OR "Lifting" OR "Carrying"
AND
"Traffic light system" OR "Traffic light criteri*" OR "Decision Making" OR "Decision making system" OR "Decision Criteria" OR "Return to work checklist" OR "Work reuptake criteria" OR "Work ability index" OR "Return to work criteria" OR Return to workOR "Work resumption" OR "Fitness assessment" OR "Fitness Test" OR "Aerobic fitness assessment" OR "Aerobic fitness test" OR "Strength assessment" OR "Strength Test" OR "Physical Assessment" OR "Guidelines for return" OR "Screening" OR "Re-injur*" OR "Reinjur*" OR "Re-injur* Risk" OR "Reinjur* Risk" OR "Functional capacity evaluation" OR "Functional capacity" OR "Functional assessment" OR "Disability evaluation" OR "Follow up stud*" OR "Sick leave" OR "Job re-entry" OR "Sustainable return to work" OR "Performance test" OR "Performance assessment" OR "Performance based test" OR "Performance based assessment" OR "Lifting test" OR "Strength test" OR "Carry test"

using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach (Brożek et al., 2009). It was used by two reviewers (LN & KM). If there was a disagreement between the two researchers, a third (either AM or JM) were used to decide on the appropriate action. The GRADE approach categorise the certainty of evidence into four levels; "High" (we are very confident that the true effect lies close to that of the estimate of effect), "Moderate" (we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different), "Low" (our confidence in the effect size is limited: the true effect many be substantially different from the estimate of the effect) and "Very Low" (we have very little confidence in the effect estimate) (Balshem et al., 2011).

3. Results

3.1. Study selection

Fig. 1 shows the study identification process. Once duplicates were removed, 2837 studies were identified. After title and abstract screening, 71 studies were considered for full text review with 5 studies remaining to be included for review.

3.2. Study characteristics

Study characteristics are described in Table 4. Studies included a total of 507 participants (Male = 309, Female = 198), all of whom were recruited from athletic occupations (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). Of the five studies included, all were cohort studies (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021), four involved participants recovering from an anterior cruciate ligament (ACL) injury (Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021) and one study involved participants recovering from a hamstring injury (De Vos et al., 2014). The mean time between injury or surgery and the return to sport screening test in the studies ranged between 40 days and 19 months (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). Three studies conducted one follow up to assess reinjury rates after 24 months (De Vos et al., 2014; Fältström et al., 2021; van Melick et al., 2021). Two studies used two separate follow ups, at 12 months and 24 months (King et al., 2021) and at 9 months and 60 months (Zore et al., 2021).

3.3. Risk of bias assessment

The risk of bias of the included studies is shown in Table 2. Four of the studies were deemed to have a low risk of bias (De Vos et al., 2014; Fältström et al., 2021; van Melick et al., 2021; Zore et al., 2021) and the remaining article was deemed to have an unclear risk of bias (King et al., 2021).

3.4. Assessment of the certainty of the body of evidence of findings

The assessment of the certainty of the body of evidence was assessed using the GRADE approach (Brożek et al., 2009). There was a very low level of certainty for the effectiveness of screening tests reducing the risk of reinjury at three separate time points (up to and including one year, up to and including two years and greater than three years) (Table 3).

3.5. Return from injury screening test used

All studies used a physical screening test to help predict if an individual was ready to return to their sport following an injury and or surgery (Table 4) (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). The physical variables measured included ROM, knee extension, knee flexion, jumping and hopping (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). One study required the participants to reach a set criterion of a limb symmetry index (LSI) > 90% for all movement quantity tests and a single leg hop and hold less than 6 on the Landing Error Scoring System (LESS) before being permitted to return to sport or play (De Vos et al., 2014).

3.6. Reinjury rates following the use of a return to sport or play screening test

All studies provided reinjury rates in participants following their return to work. Four studies involved participants after an ACL injury (Fältström et al., 2021; King et al., 2021; van Melick et al.,

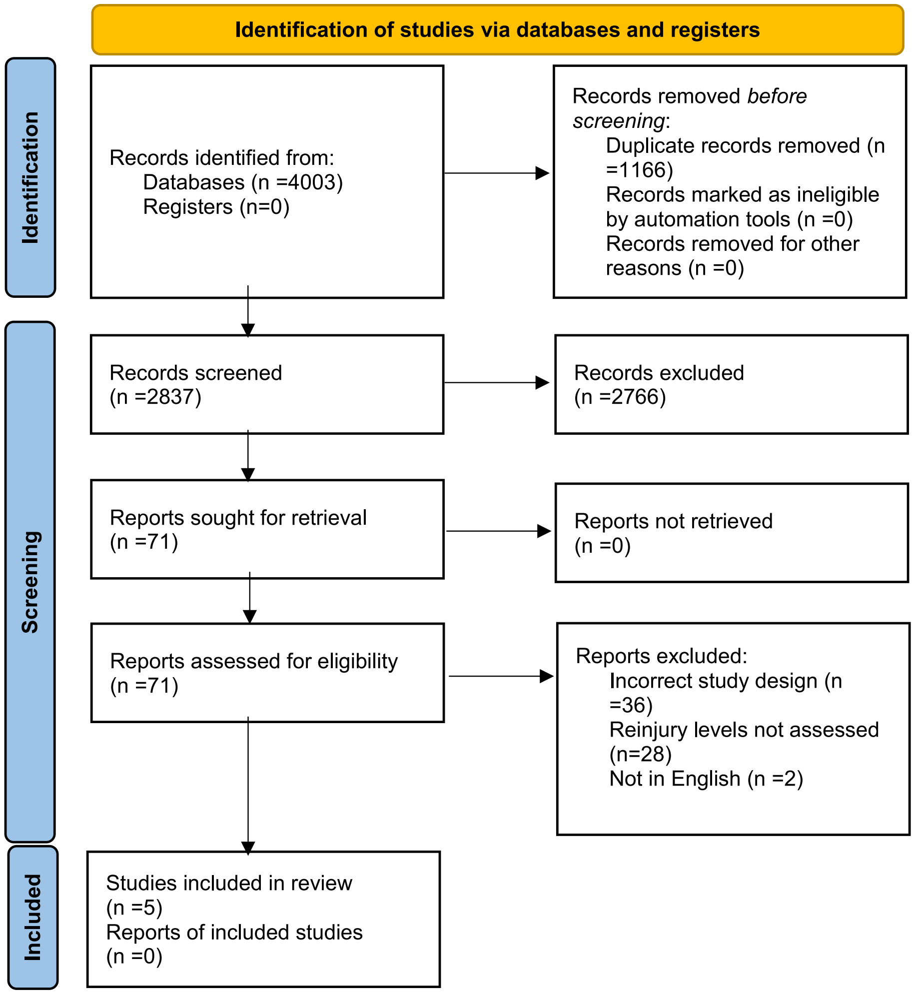

Fig. 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only (Black et al., 2018).

Table 2
Risk of bias assessment of included studies using the Newcastle Ottawa Scale (NOS).

Author (Year)	Selection	Comparability	Exposure/Outcome	Total Stars	Risk of Bias
(De Vos et al., 2014)	****	**	***	9	Low
(Fältström et al., 2021)	****	**	***	9	Low
(King et al., 2021)	****	*	*	5	Unclear
(van Melick et al., 2021)	****	**	**	8	Low
(Zore et al., 2021)	****	*	**	7	Low

Table 3
Assessment of the certainty of the body of evidence findings of reinjury rates following the use of screening tests taken across three time points, with Grading of Recommendations Assessment, Development and Evaluation (GRADE). *Note:* * Downgraded once for risk of bias, ** Downgraded once for inconsistency, *** Downgraded once for imprecision.

Outcome by time point	Studies	No. of studies	Type of studies	No. of participants	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Level of certainty
≤1 year	(De Vos et al., 2014)	1 study	1 cohort study	64	−1	−1	No	−1	Undetected	*,***Very Low
≤2 years	(Fältström et al., 2021) (King et al., 2021) (van Melick et al., 2021)	3 studies	3 cohort studies	380	−1	−1	No	−1	Undetected	*,**,***Very Low
≥3 years	(Zore et al., 2021)	1 study	1 cohort study	63	No	No	No	−1	Undetected	***Very Low

Table 4
Study characteristics. SD = Standard Deviation, ACL = Anterior Cruciate Ligament, ACLR = Anterior Cruciate Ligament Reconstruction, ROM = Range of motion, RI = Reinjury group, NRI = No reinjury group, SD = Standard deviation, N = Number of participants, M = Male, F= Female, RTP = Return to play, LSI = Limb Symmetry Index, EPIC = Estimated Preinjury Capacity, EPIC- H = Estimated preinjury capacity of uninvolved limb.

Reference (Year)	Study Design	Area of injury	Sample size	Gender	Mean Age (Year)	Physical Occupation	Outcome measure	Screening test used	Duration away from sport (Mean ± SD)	Follow up time after assessment	Returned to sport participation	Reinjury Rates following RTS/RTP assessment
(De Vos et al., 2014)	Cohort Study	Hamstring	N = 64	M = 61 F = 3	28 (Black et al., 2018; de Waard et al., 2017; Delgado-Noguera et al., 2015; Gates et al., 2018; Hägglund et al., 2007; Houghton et al., 2016; Noll et al., 2021; Page et al., 2021; Stang, 2010; Sullivan & Feinn, 2012; Tol et al., 2014)	Soccer (N = 45) Futsal (N = 1) Field Hockey (N = 11) Athletics (N = 4) Tennis (N = 1) American football (N = 1) Fitness (N = 1)	Hamstring reinjury rates	Active knee extension test Passive straight leg raise.	40 days (31 −55 days)	12-month post initial injury	N = 64	N = 17 (27%)
(Fältström et al., 2021)	Cohort Study	ACL	RI = 28 NRI = 89	F = 117	RI = 20 ± 3 NRI = 20 ± 2	Soccer (N = 117)	ACL reinjury rates	Knee extension LSI on single hop for distance(%) LSI on side hop (%) 5-jump test (cm) Tuck jumps	19 (±9) months	24-months post ACL reconstruction	N = 117	N = 28 (24%)
(King et al., 2021)	Cohort Study	ACL	RI = 31 NRI = 57	M = 88	RI = 21.7 (±4.9) NRI = 22.9 (±4.1)	Gaelic Football RI (N = 16) NRI (N = 23) Hurling RI (N = 6) NRI (N = 14) Soccer RI (N = 5) NRI (N = 11) Rugby RI (N = 4) NRI (N = 9)	ACL reinjury rates	Quadricep LSI Hamstring LSI Single leg countermovement jump Single leg drop jump Single leg hop for distance Double leg drop jump (knee flexion, centre of mass to ankle vertical distance and ground contact time))	RI = 9.1 (±3.1) months NRI = 9.3 (±1.2) months	12-months and 24-months post-surgery	N = 88	N = 31 (35%)
(van Melick et al., 2021)	Cohort Study	ACL	N = 175	M = 123 F = 52	24 ± 6	Soccer (N = 129) Volleyball (N = 9) Handball (N = 8) Hockey (N = 7) Korfball (N = 6) Basketball (N = 5) Other pivoting sport (N = 11)	ACL reinjury rates	Strength test battery Hop test battery Movement quantity tests combined Hop and hold CMJ with LESS Movement quality tests combined Movement quantity and quality combined	11.8 months (±2.9)	24-months post surgery	N = 102	N = 7 (5%)

(continued on next page)

Table 4 (*continued*)

Reference (Year)	Study Design	Area of injury	Sample size	Gender	Mean Age (Year)	Physical Occupation	Outcome measure	Screening test used	Duration away from sport (Mean ± SD)	Follow up time after assessment	Returned to sport participation	Reinjury Rates following RTS/RTP assessment
(Zore et al., 2021)	Cohort Study	ACL	N = 63	M = 37 F = 26	34.7 (SD = 12.3)	Professional or recreational sports (N = 63)	ACL reinjury rates	Knee extension LSI Peak torque (ACLR) Peak torque (uninvolved) EPIC EPIC-H Knee flexion LSI Peak torque (ACLR) Peak torque (uninvolved) EPIC EPIC-H	8.5 months (±9.03)	Short term (9 months) following ACL reconstruction. Medium term (60 months) following ACL reconstruction.	N = 63	N = 12 (19%)

2021; Zore et al., 2021), reporting reinjury rates of 24% (Fältström et al., 2021), 35% (King et al., 2021), 5% (van Melick et al., 2021) and 19% (Zore et al., 2021). One study involved participants after a hamstring injury (De Vos et al., 2014), reporting a reinjury rate of 27% following a return to sport or play respectively.

3.7. *Reinjury rates following the use of a screening test across different time points*

The extracted data presented in Tables 5–7 provided three time points at which reinjury rates were recorded. Short-term (≤1 year), medium-term (≥2 years) and long-term (≥3 years). If effect size was not reported it was calculated manually using Cohen's *d* and magnitude of effect size (Chen et al., 2010).

3.8. *Short-term (<1 year)*

One cohort study (De Vos et al., 2014) reported a very low certainty for the effectiveness of screening tests in reducing the risk of reinjury up to and including one year. In the context of this very low certainty, one screening test assessing deficit in knee extension and passive straight leg raise, the effect size was not reported. Knee extension deficit reported a between groups *p* value of 0.059 and passive straight leg raise reported a between group *p* value of 0.376 (Table 5).

3.9. *Medium term (≥2 years)*

Three cohort studies (Fältström et al., 2021; King et al., 2021; van Melick et al., 2021) reported very low certainty for the effectiveness of screening tests reducing the risk of reinjury up to an including two years. In the context of this very low certainty, two tests, demonstrated a small effect in LSI on hopping distance (Fältström et al., 2021; King et al., 2021) and quadricep and hamstring strength for reducing the risk of reinjury (Fältström et al., 2021; King et al., 2021). Two return to screening tests, double leg 5-jump test and double leg drop jump, demonstrated a medium effect for reducing the risk of reinjury (Fältström et al., 2021; King et al., 2021). One study did not report effect size but did report relative risk for some of the screening tests (van Melick et al., 2021) Strength test battery screening tests reported a relative risk of 2.95 (0.37–23.51). Hop and hold screening tests reported a relative risk of 10.17 (1.28–81.10). Counter movement jump (CMJ) with the landing error scoring system reported a relative risk of 2.16 (0.44–10.62). Movement quality tests combined reported a relative risk of 3.86 (0.48–30.85) (van Melick et al., 2021).

3.10. *Long term (≥3 years)*

One cohort study (Zore et al., 2021) reported very low certainty for the effectiveness of screening tests reducing the risk of reinjury greater than three years. In the context of this very low certainty, one screening test, demonstrated a small effect size in limb symmetry index (LSI) in both knee extension and flexion for reducing the risk of reinjury. One screening test, peak torque, demonstrated medium effect during knee extension and small effect during knee flexion in both the leg with ACL reconstruction and the uninvolved leg for reducing the risk of reinjury. One screening test, Estimated Preinjury Capacity (EPIC) demonstrated a large effect during knee extension and a medium effect during knee flexion in both the leg with ACL reconstruction and the uninvolved leg for reducing the risk of reinjury.

4. Discussion

The aim of this systematic review was to identify current RTW screening tests conducted for athletic occupations following injury and understand their effectiveness for reducing reinjury risk. To the authors' knowledge, this is the first review of its kind. Overall, there was very low certainty for the effectiveness of the use of screening tests for reducing the risk of reinjury. Whilst this review does identify data indicating screening tests can reduce the risk of reinjury, the low level of certainty of these findings indicate that they should be interpreted with caution.

All studies used in this review assessed a population of professional athletes returning to a sporting occupation following an injury (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). No studies were found involving tactical athletes, highlighting a shortfall in our understanding for the use of screening tests in tactical athletes returning to work following injury. All studies in this review assessed ACL and hamstring injuries (De Vos et al., 2014; Fältström et al., 2021; King et al., 2021; van Melick et al., 2021; Zore et al., 2021). Athletic occupations are at risk of sustaining other musculoskeletal injuries with injuries to the back, ankle, shoulder and hip common in these populations (Gray & Finch, 2015; Noll et al., 2021; Orr et al., 2019). Therefore, further research is needed to assess the effectiveness of screening tests in reducing reinjury risk for a range of musculoskeletal injuries.

The screening tests found in this review assessed a range of elements to assess their association with risk of reinjury. These elements were knee extension peak torque (De Vos et al., 2014; Fältström et al., 2021; Zore et al., 2021), knee flexion peak torque (Zore et al., 2021), LSI (Fältström et al., 2021; King et al., 2021; Zore et al., 2021), hop and jumping tests (Fältström et al., 2021; King et al., 2021; van Melick et al., 2021) and EPIC (Zore et al., 2021). The use of EPIC was the only screening test which reported a large effect size (Zore et al., 2021), highlighting the importance that failure to regain knee function prior to Anterior Cruciate Ligament Reconstruction (ACLR) may cause an increased risk for a second ACL injury (Zore et al., 2021). EPIC compared the strength of the previously injured limb of an individual returning to an athletic occupation with the strength of the non-injured limb immediately after the injury or surgery (Zore et al., 2021). Individuals with greater percentage loss to both muscle and strength in their rehabilitating limb were at increased risk of suffering a secondary reinjury (Hannon et al., 2017; Zore et al., 2021).

Because of the increased injury risk, many athletic occupations require individuals to maintain certain strength standards to enable them to perform their job role safely and effectively (Rayson et al., 2000; Siddall et al., 2016). Previous studies have suggested that failure to retain physical standards and poor performances during physical assessments could increase injury risk (Morris et al., 2021; Sarah et al., 2017; Stevenson et al., 2017).

The use of a screening test for athletic occupations aiming to RTW following injury has the potential to assess if the rehabilitated limb is able to achieve at least the minimum physical demands of the workplace tasks before a RTW, as returning prematurely has seen associated increases in reinjury risks (Kaplan & Witvrouw, 2019; Nosanov & Romanowski, 2020). The interpretation from this review indicates that screening for reinjury risk should be comprised of multiple tests to reduce the risk of reinjury when compared to using a single test, with an importance focused on muscular strength (van Melick et al., 2021; Zore et al., 2021). One study in this review claimed that the use of multiple tests assessing jump height, jump length and running change of direction times may offer more accurate information relating to reinjury risk compared to using tests in isolation (King et al., 2021).

In the absence of research on the use of RTW screening tests for tactical athletes following injury and their effectiveness at reducing reinjury risk, further research is required. Currently, multiple tests of aerobic fitness and muscular strength are used in the selection process in tactical athletes including the military, the police and the fire service (Orr et al., 2018; Rayson et al., 2000; Stevenson et al., 2017). Previous research in tactical athletes has provided national recommendations for entry level aerobic fitness and muscular strength standards to ensure that potential candidates are able to reach the job task demands before employment (Morris et al., 2019; Rayson et al., 2000; Siddall et al., 2016; Stevenson et al., 2016).

Many tactical athletes are assessed on their aerobic fitness and muscular strength based on generic tasks experienced during active duties (including weighted carries, weighted lifts and running) (Rayson et al., 2000; Stevenson et al., 2017). These selection tests were created to assess if an individual could achieve the minimum physical attributes required to undertake the task demands of a their role (Rayson et al., 2000; Stevenson et al., 2017). The use of generic tasks during the selection tests required no specialised training, making it possible for them to be used on civilian population (Rayson et al., 2000; Stevenson et al., 2017). However, once employed as a tactical athlete, individuals are trained in more specific tasks related to their job role (Mazzetti, 2013; Strader et al., 2020). Therefore, it may not be suitable to use the generic tasks from selection process tests alone when aiming to reduce reinjury risk for tactical athletes returning following an injury. Instead, return to work screening tests could involve more specific tasks relating to the individuals job task demands.

Previous research has used physical assessment tests for tactical athletes to predict injury rates (Orr et al., 2021). Low levels of aerobic fitness and muscular strength were associated with a high risk of injury whilst on duty (Orr et al., 2021). However, previous research predicting injury risk in tactical athletes included only participants who were physically healthy and with no recent injury (Bock & Orr, 2015; Kollock et al., 2018; Tomes et al., 2020). No research on screening tests aimed at reducing reinjury risk for tactical athletes return to duty following an injury currently exists.

If a screening test could help to reduce the risk of a reinjury in athletic occupations, it could be advantageous for the employer as it could result in fewer days employees were absent from the workplace and lower expenses from sick pay for the organisation (Griffin et al., 2016; Hilyer et al., 1990).

4.1. Strengths and limitations

This review is the first of its kind to evaluate the current screening tests used in tactical athletes and their effectiveness in reducing the risk of reinjury. These findings are robust given the

Table 5
Reinjury rates following the use of screening tests in short term follow-up (≤1 year).

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
(De Vos et al., 2014)	Hamstring	Cohort	Hamstring reinjury rates	12 months	Active knee extension deficit	Not reported	Not reported	0.059
					Passive straight leg raise			0.376

Table 6
Reinjury rates following the use of screening tests in medium term follow-up (≥2 years). ACL = Anterior Cruciate Ligament, LSI = Limb Symmetry Index, CMJ = Countermovement jump, LESS = Landing Error Scoring System. *Significant Difference ($P = \leq 0.05$) **Relative Risk.

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
(Fältström et al., 2021)	ACL	Cohort	ACL reinjury rates	24 months	Knee extension	0.39	Small	0.044*
					LSI on single hop for distance(%)	0.12	Small	0.630
					LSI on side hop (%)	0.24	Small	0.237
					5-jump test (cm)	0.55	Medium	0.007*
					Tuck jumps	0	None	0.286
(King et al., 2021)	ACL	Cohort	ACL reinjury rates	24 months	Quadricep LSI	0.1	Small	0.652
					Hamstring LSI	0.24	Small	0.275
					Single leg countermovement jump	0.01	Small	0.964
					Single leg drop jump	0.19	Small	0.445
					Single leg hop for distance	0.21	Small	0.388
					Double leg drop jump (knee flexion, centre of mass to ankle vertical distance and ground contact time)	0.52–0.64	Medium	0.21–0.3
(van Melick et al., 2021)	ACL	Cohort	ACL reinjury rates	24 months	Strength test battery	2.95 (0.37 –23.51)**	Not reported	0.420
					Hop test battery	Not reported	Not reported	0.047*
					Movement quantity tests combined	Not reported	Not reported	0.348
					Hop and hold	10.17 (1.28 –81.10)**	Not reported	0.010*
					CMJ with LESS	2.16 (0.44 –10.62)**	Not reported	0.445
					Movement quality tests combined	3.86 (0.48 –30.85)**	Not reported	0.240
					Movement quantity and quality combined	Not reported	Not reported	0.591

Table 7
Reinjury rates following the use of screening tests in long term follow-up (≥3 years). ACL = Anterior Cruciate Ligament, ACLR = Anterior Cruciate Ligament Reconstruction, LSI = Limb Symmetry Index, EPIC = Estimated Preinjury Capacity, EPIC- H = Estimated preinjury capacity of uninvolved limb. *Significant difference ($P = \leq 0.05$).

Study	Area of Injury	Design	Outcome Measure	Follow up	Return to Sport/Play assessment	Effect Size	Magnitude	Between groups *P*-value
(Zore et al., 2021)	ACL	Cohort	ACL reinjury rates	5 Years	**Knee extension**			
					LSI	0.15	Small	0.663
					Peak torque (ACLR)	0.53	Medium	0.114
					Peak torque (uninvolved)	0.54	Medium	0.096
					EPIC	0.84	Large	0.028*
					EPIC-H	1.6	Large	<0.001*
					Knee flexion			
					LSI	0.12	Small	0.664
					Peak torque (ACLR)	0.38	Small	0.258
					Peak torque (uninvolved)	0.35	Small	0.251
					EPIC	0.52	Medium	0.127
					EPIC-H	0.6	Medium	0.052

adherence to PRISMA 2020 guidelines. This review highlighted several limitations of the evidence found. Firstly, a very low level of certainty was found at all three time points for reinjuries. Secondly, only cohort studies were found during the search and all studies involved individuals returning to sport. No studies were identified for any tactical athletes returning to duty following an injury. Finally, language was restricted to English language only.

5. Conclusion

This review sought to investigate screening tests amongst all athletic occupations. The results demonstrated very low level of certainty for the effectiveness of RTW screening tests reducing the risk of reinjury. The use of EPIC reported a large effect size and highlighted the importance of regaining muscular strength in the rehabilitating limb before a RTW in professional sport athletes (Zore et al., 2021). Interpretation from this review indicates that the use of multiple tests of muscular strength and endurance are more beneficial than the use of a singular test in isolation (van Melick et al., 2021; Zore et al., 2021). A gap in our understanding currently exists for RTW screening tests in tactical athletic occupations. Research is required to investigate the effectiveness of RTW screening tests for tactical athletes returning to work following injury.

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Declaration of competing interest

All authors declare they have no conflict of interests.

Appendix A. Supplementary data

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