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Return-to-Sport Readiness After Ankle Sprain Rehabilitation: Associations Between Balance, Strength, Pain, and Functional Performance

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ABSTRACT: Return-to-sport decisions after ankle sprain rehabilitation often rely on clinical impression, time since injury, or absence of pain, although persistent balance deficits, strength asymmetry, and reduced functional performance can remain after symptoms improve. This study examined associations between dynamic balance, ankle strength symmetry, pain, patient-reported function, hop performance, and return-to-sport (RTS) readiness among male and female athletes completing rehabilitation after lateral ankle sprain. We used a cross-sectional discharge-assessment design with 168 athletes aged 16-32 years (86 men and 82 women) who completed a supervised rehabilitation program and final RTS testing. We classified readiness based on a multidisciplinary discharge decision, including no swelling, pain no greater than 2/10 during sport-specific tasks, a functional hop limb symmetry index (LSI) of at least 90%, and clinician clearance. We assessed dynamic balance with the Y-Balance composite score, ankle strength with handheld dynamometry LSI, pain with an 11-point numeric rating scale, patient-reported sport function with the Foot and Ankle Ability Measure-Sport subscale, and functional performance with single-hop LSI. We set statistical significance at $p < 0.05$. Ninety-six athletes (57.1%) met the RTS-ready classification. Compared with athletes not classified as ready, the RTS-ready group showed moderately higher Y-Balance scores (92.1 +/- 5.4 vs. 89.2 +/- 6.1), ankle strength LSI (92.3 +/- 7.2 vs. 89.0 +/- 8.2), FAAM-Sport scores (88.3 +/- 8.6 vs. 83.4 +/- 9.2), and hop LSI (90.8 +/- 6.8 vs. 87.0 +/- 7.3), and lower sport-task pain (1.4 +/- 0.9 vs. 2.0 +/- 1.1; all $p <= 0.007$). RTS composite readiness was most strongly correlated with hop LSI ($r = 0.53$), FAAM-Sport ($r = 0.49$), pain ($r = -0.46$), and dynamic balance ($r = 0.41$). In adjusted logistic regression, hop LSI, pain, FAAM-Sport, and dynamic balance remained significant or borderline-significant predictors of readiness, while strength symmetry contributed modestly. The findings support a multidimensional RTS assessment after ankle sprain rehabilitation, because readiness was associated with concurrent balance control, functional capacity, pain response, and athlete-reported sport confidence rather than any single discharge measure.

Keywords: ankle sprain; rehabilitation; functional performance; Y-Balance Test; FAAM-Sport.

I. INTRODUCTION

Lateral ankle sprain is one of the most common injuries in sport and exercise settings, and its apparent simplicity can mask a complex recovery process. Athletes, coaches, and clinicians often expect a rapid return because swelling may decrease quickly and walking pain may resolve within days or weeks. However, sport participation requires more than ordinary walking tolerance. A safe, confident return requires repeated acceleration and deceleration, landing, cutting, pivoting, jumping, rapid changes of direction, and the ability to respond to unplanned contact or movement. These demands require strong joint stability, sensorimotor control, strength, confidence, and pain-free function. A player who can walk without pain may still be unable

to control the injured limb during a single-leg landing or recover balance during a sudden change of direction. For this reason, return-to-sport readiness after ankle sprain rehabilitation should be understood as a performance state rather than a calendar date.

A systematic review of ankle injury in sport reported that ankle sprain is common across many sport activities and that the lateral ligament complex is frequently involved [1]. A later systematic review of ankle sprain incidence and prevalence showed that ankle sprain is not restricted to elite sport and occurs across age groups, sexes, and sport settings [2]. These findings matter because many community and school settings treat ankle sprain casually. Athletes may return to play as soon as pain is tolerable, particularly when competitions are ongoing, or team availability is limited. Yet recurrent ankle sprain, perceived instability, and chronic ankle instability remain common concerns after an initial injury, especially when rehabilitation and discharge decisions do not address sensorimotor deficits and sport-specific function.

The international research consortium emphasized that lateral ankle sprain and chronic ankle instability require consistent terminology and careful reporting of mechanical and functional impairments [3]. This matters for return-to-sport research because studies may define recovery, instability, reinjury, and readiness differently. Some athletes are considered recovered because they have returned to participation; others are considered recovered because they are pain-free at rest; others are classified according to mechanical laxity, balance, or patient-reported function. These definitions are not interchangeable. Athletes may return to participation before recovery is complete, and pain-free status at rest may not predict tolerance of sport tasks. The present study therefore frames readiness as a multidimensional clinical decision that combines physical testing, pain response, athlete-reported function, and clinician judgment.

The recent PAASS framework for return-to-sport decisions after acute lateral ankle sprain provides a useful clinical structure by identifying five domains: pain, ankle impairments, athlete perception, sensorimotor control, and sport or functional performance [4]. This framework is valuable because it moves decision-making beyond a narrow focus on pain or time since injury. It also reflects the way clinicians make real decisions. An athlete may have good strength but poor balance, or low pain but low confidence, or acceptable hop distance but symptoms during repeated sport-specific tasks. The challenge for sport medicine is not only to identify whether each domain matters, but also to understand how these domains relate to one another at the point of discharge from rehabilitation.

Systematic-review evidence on return to sport after lateral ankle sprain indicates that many studies use incomplete or inconsistent criteria, and that stronger, criteria-based approaches are needed [5]. Clinical practice guidelines similarly emphasize interventions and assessments addressing pain, movement, strength, balance, and functional activity after ankle ligament sprain [6]. In clinical settings, however, the pressure to return athletes quickly may encourage simplified judgments. The athlete may ask whether he or she is ready, the coach may ask whether the athlete can play this weekend, and the clinician may need to translate several test findings into a decision that is both practical and defensible. This situation requires a manageable battery of tests that can be completed in the field or clinic and that reflects the actual demands of sport.

Balance assessment is central because ankle sprain can disrupt proprioception, neuromuscular control, and the athlete's ability to maintain stability during single-limb tasks. Dynamic balance tests, including reach-based tasks, are attractive because they require the athlete to combine ankle, knee, hip, and trunk control under a functional challenge. They are also relatively easy to use in clinical and sports medicine settings. Poor dynamic balance after ankle sprain may reflect persistent sensorimotor impairment even when swelling and resting pain have improved. For athletes returning to sports that involve jumping, landing, and direction changes, balance deficits are clinically meaningful because they can affect both performance and reinjury risk.

Ankle sprain can reduce strength through pain inhibition, altered loading, neuromuscular changes, and incomplete restoration of peroneal and plantarflexor function. Strength deficits may not always be obvious during ordinary gait, but they can appear during high-demand tasks such as repeated hops, sprint starts, or lateral movements. Limb symmetry indexes are commonly used because they express the injured limb relative to the uninjured limb. Although symmetry alone cannot guarantee readiness, a large strength deficit may indicate incomplete physical restoration and may contribute to altered mechanics during sport.

Low pain during daily activity does not automatically mean that an athlete can tolerate sport. Conversely, mild pain during a controlled rehabilitation task does not necessarily mean that sport return is impossible. The timing, intensity, and context of pain are important. Pain during hopping, cutting, or sport-specific drills may signal insufficient tissue tolerance, confidence, or neuromuscular control. Pain can also interact with performance: an athlete with pain may protect the injured limb, reduce push-off force, shorten hop distance, or avoid end-range dorsiflexion during landing. Therefore, interpret pain alongside strength, balance, and functional performance rather than as an isolated discharge criterion.

Functional performance testing bridges impairment measures and sport demands. Hop tests are especially useful because they require force production, landing control, confidence, and tolerance of rapid loading. The Foot and Ankle Ability Measure-Sport subscale adds the athlete's perspective, which is essential because readiness includes perceived ability to perform sport-specific tasks. An athlete who achieves acceptable objective scores but reports poor sport function may not be psychologically or functionally prepared for full participation. Similarly, an athlete who reports confidence but shows marked hop asymmetry may be at risk if returned without further rehabilitation. A combined approach offers a clearer picture than either objective or subjective measures alone.

Men and women should both be represented in return-to-sport research because ankle sprain and rehabilitation outcomes occur across sexes and sport contexts. Sex-related differences may exist in sport exposure, movement strategy, neuromuscular control, and injury risk, but clinical decisions cannot rely on sex alone. Athletes within the same sex can vary widely in sport level, previous injury history, pain tolerance, strength, and balance. A mixed sample allows the analysis to test whether the main associations remain after accounting for sex while still producing findings that are relevant to typical sport medicine practice.

The present study examined return-to-sport readiness after ankle sprain rehabilitation by evaluating associations among dynamic balance, ankle strength symmetry, pain, athlete-reported function, and hop-based functional performance. The goal was not to replace clinician judgment with a single score. Instead, the study aimed to clarify which discharge variables most closely related to readiness classification and whether a multidimensional assessment coherently explains clinical decisions. This approach is intended to support more transparent return-to-sport reasoning after ankle sprain rehabilitation and to encourage decisions based on the combined status of pain, balance, strength, and sport function.

1. AIMS AND HYPOTHESES

Aims:

- To compare balance, ankle strength symmetry, pain, patient-reported sport function, hop performance, and RTS composite scores between athletes classified as ready and not ready after ankle sprain rehabilitation.
- To examine bivariate associations among balance, strength, pain, FAAM-Sport, hop LSI, and RTS composite readiness.
- To determine which variables independently predict RTS readiness after adjustment for sex, age, previous ankle sprain, and rehabilitation duration.
- To evaluate whether readiness patterns are broadly consistent in a mixed sample of male and female athletes.

Hypotheses:

- Athletes classified as RTS-ready will show higher dynamic balance scores than athletes not classified as ready.
- Athletes classified as RTS-ready will show higher ankle strength limb symmetry and hop limb symmetry than athletes not classified as ready.
- Athletes classified as RTS-ready will report lower pain and higher FAAM-Sport scores than athletes not classified as ready.
- Hop performance, pain, FAAM-Sport, and dynamic balance will show the strongest associations with RTS composite readiness.
- Functional performance and pain will remain independent predictors of readiness after adjustment for sex, age, previous ankle sprain, and rehabilitation duration.

II. LITERATURE REVIEW

Ankle sprain rehabilitation has shifted from a narrow focus on ligament healing to a broader focus on function, perception, and sport-specific readiness. Earlier epidemiological research established that ankle sprain is one of the most common injuries in sport, but the clinical challenge lies in what happens after the initial injury [1], [2]. Many athletes return to sport before all impairments resolve, which may contribute to recurrence or long-term instability. The International Research Consortium clarified terminology by distinguishing acute lateral ankle sprain, recurrent sprain, perceived instability, and chronic ankle instability [3]. This distinction is essential because an athlete may have returned to sport but still experience instability, giving-way episodes, or reduced confidence. Return-to-sport readiness should therefore be assessed as a state of restored function, not merely as evidence that the athlete has resumed participation.

The PAASS framework is particularly relevant because it identifies pain, ankle impairments, athlete perception, sensorimotor control, and sport or functional performance as key domains in return-to-sport decisions after acute lateral ankle sprain [4]. The framework has practical value because it reflects the complexity clinicians face at discharge. Pain can be low while balance remains poor; strength can improve while sport confidence remains limited; hop distance can be acceptable while landing quality is poor. A readiness decision based on only one domain may therefore miss important deficits. The present study adopts this multidimensional view by examining balance, strength symmetry, pain, patient-reported sport function, and hop performance together.

A systematic review of return-to-sport criteria after lateral ankle sprain concluded that decision criteria are often poorly defined and that objective measures are used inconsistently [5]. This is a major problem for sport medicine because unclear criteria make it difficult to compare studies, guide clinicians, or explain decisions to athletes and coaches. Clinical practice guidelines for ankle stability and movement coordination impairments also emphasize assessing and treating pain, swelling, range of motion, strength, balance, and activity limitations after ligament sprain [6]. The shared message across these sources is that return to sport should be based on criteria rather than time alone.

Return-to-play discussions after ankle sprain also emphasize that the decision should account for tissue healing, functional capacity, sport demands, and risk tolerance [7]. In competitive environments, external pressures often shape return decisions, including team needs, athlete motivation, and competition schedules. These pressures can lead to early return if the athlete appears symptom-free during basic activity. However, sport readiness is better evaluated under tasks that resemble sport requirements. The gap between daily function and sport function matters for ankle sprain because cutting, jumping, and landing expose deficits not visible during walking.

The selection criteria for chronic ankle instability also support rigorous RTS assessment. The International Research Consortium's position statement on research selection criteria highlights the importance of documenting recurrent sprain, giving way, perceived instability, and functional limitation [8]. Although this study focuses on post-rehabilitation readiness rather than diagnosing chronic ankle instability, the same impairments can begin during early recovery. A discharge assessment that identifies poor balance, pain, or functional asymmetry may help prevent a progression from acute injury to recurrent problems.

The updated model of chronic ankle instability describes interactions among mechanical instability, sensorimotor deficits, perceived instability, and functional limitations [9]. This model is useful because it does not treat ankle function as a simple mechanical problem. An athlete's readiness depends on the interaction between physical capacity and perception. For example, an athlete may demonstrate adequate strength but still guard the ankle because of perceived instability. Another may feel confident but show poor dynamic balance. These mixed presentations explain why multidimensional assessment is important at the end of rehabilitation.

McKeon and Hertel's systematic review and meta-analysis showed that postural control and balance assessment can distinguish individuals with chronic ankle instability from healthy controls [10]. Their companion review reported that balance training can improve outcomes in people with chronic ankle instability [11]. Although chronic instability differs from acute recovery, these findings support the clinical relevance of restoring balance. Dynamic balance testing at discharge can indicate whether rehabilitation has restored functional control of the injured limb under single-leg demand.

Additional meta-analytic evidence supports the role of balance impairment after lateral ankle sprain and chronic ankle instability. Wikstrom and colleagues reported altered dynamic postural stability and balance capabilities in people with chronic ankle instability [12]. Arnold and colleagues reported balance impairments in individuals with chronic ankle instability compared with controls [13]. These findings suggest that balance is not a minor accessory outcome but a central component of ankle function. In return-to-sport assessment, poor dynamic balance may indicate that the athlete is not yet prepared for unpredictable sport actions, even when pain is low.

Evertor and invertor strength deficits have been reported in chronic ankle instability and are often interpreted as part of the neuromuscular deficit profile after ankle sprain [14]. Strength restoration is clinically important because ankle musculature contributes to joint control, push-off, deceleration, and protection against inversion stress. Handheld dynamometry is practical in clinic and field settings, and limb symmetry indexes can help clinicians interpret injured-limb recovery relative to the uninjured side. However, strength symmetry alone may not capture readiness if the athlete still has poor balance, pain, or reduced sport confidence.

The Foot and Ankle Ability Measure was developed to assess physical function in people with musculoskeletal disorders of the lower leg, foot, and ankle [15]. The FAAM-Sport subscale is especially relevant for athletes because it asks about running, jumping, landing, cutting, and sport-specific tasks. Carcia and colleagues supported using the FAAM in athletes with chronic ankle instability [16]. Including FAAM-Sport in RTS decisions recognizes that athletes are experts in their own sport, confidence, and perceived limitations. A low score at discharge may reflect unresolved symptoms, fear, instability, or lack of trust in the ankle during demanding activity.

The Cumberland Ankle Instability Tool also contributes to assessing perceived ankle instability [17]. Although it was designed to identify and quantify functional ankle instability, it is also important for return-to-sport decisions. Athletes may report instability that strength testing or routine examination does not reveal. Perceived instability can alter movement behavior, reduce confidence, and increase caution during play. This study used FAAM-Sport rather than CAIT as the primary patient-reported sport-function measure, but the broader literature supports including patient perception in discharge testing.

The Star Excursion Balance Test and its simplified reach directions have become widely used tools for assessing dynamic balance [18]. Plisky and colleagues reported that reach deficits and asymmetries were associated with lower-extremity injury risk in high school basketball players [19]. Although predicting future injury differs from assessing readiness after rehabilitation, the underlying principle remains relevant: dynamic balance tasks can reveal movement-control limitations that static clinical examination does not capture. The Y-Balance Test, derived from the Star Excursion Balance Test, is attractive in clinical practice because it provides a standardized, time-efficient way to measure anterior, posteromedial, and posterolateral reach performance.

Hop testing is frequently used after lower-limb injury because it requires strength, coordination, pain tolerance, confidence, and landing control. Caffrey and colleagues showed that hop tests can help identify functional deficits in people with chronic ankle instability [20]. In rehabilitation settings, hop limb symmetry indexes provide a practical indicator of whether the injured limb can produce and accept force similarly to the uninjured limb. Hop performance should not be the sole basis for an RTS decision, but it can serve as a strong functional marker when combined with pain, balance, and athlete-reported function.

Return-to-sport consensus work across sport injury emphasizes that return should be viewed as a continuum, not a single point [21]. Athletes may progress from return to participation to return to sport to return to performance. This distinction is useful after ankle sprain. A clinician may allow modified training before full competition, or return to sport before the athlete has returned to preinjury performance level.

Powden and colleagues reviewed the weight-bearing lunge test and supported its reliability and responsiveness as a measure of closed-chain dorsiflexion [22]. Hoch and colleagues reported that dorsiflexion range of motion was related to dynamic balance deficits in people with chronic ankle instability [23], and later work showed links between dorsiflexion and self-reported function [24]. Although the present study emphasized balance, strength, pain, and functional performance, dorsiflexion is clinically important because limited dorsiflexion may affect landing, squat depth, deceleration, and reach tasks.

The National Athletic Trainers' Association position statement on ankle sprains recommends prevention, clinical evaluation, rehabilitation, and careful return-to-play decision-making [25]. Rehabilitation should address range of motion, strength, neuromuscular control, balance, sport-specific movement, and recurrence prevention. Exercise-based rehabilitation has been shown to reduce recurrent ankle sprain and improve functional outcomes, although the magnitude of effects varies across studies [26], [27]. These findings support testing athletes after rehabilitation rather than assuming program completion automatically means readiness.

A systematic review and meta-analysis reported sex-related differences in ankle sprain rates and risk profiles [28]. However, sex should not be used as a substitute for individual assessment. Two athletes of the same sex may differ substantially in sport exposure, previous sprain history, strength, balance, and pain response. The present mixed-sex sample therefore treats sex as an adjustment variable while focusing on the readiness measures that can be modified and interpreted clinically.

Epidemiology highlights the problem's frequency and recurrence [1], [2]. Consensus and guideline work emphasize the need for criteria-based assessment [3]-[7]. Balance and strength studies show that impairments can persist after symptoms improve [10]-[14]. Patient-reported outcome research shows that athlete perceptions provide additional information [15]-[17]. Functional tests such as Y-Balance and hop performance connect impairment measures with sport demands [18]-[20].

III. MATERIAL AND METHOD

1. STUDY DESIGN

A cross-sectional discharge-assessment design was used. Athletes were assessed at the completion of a supervised ankle sprain rehabilitation program and before return to unrestricted sport participation. We selected this design because it addressed the clinical question at discharge: whether objective and patient-reported measures were associated with a readiness classification. The study followed a quantitative field-assessment structure with standardized clinical tests, patient-reported measures, and statistical modeling of RTS readiness.

2. PARTICIPANTS AND SETTING

The sample comprised 168 athletes aged 16-32 years who had completed rehabilitation after a unilateral lateral ankle sprain. The sample included 86 men and 82 women from football, basketball, volleyball, handball, futsal, tennis, athletics, and recreational running. Athletes were eligible if they had sustained a lateral ankle sprain diagnosed by a clinician, completed supervised rehabilitation, returned to pain-free walking, and completed the final discharge test battery. Exclusion criteria were fracture, syndesmotic sprain requiring prolonged immobilization, previous ankle surgery, neurological disorder affecting balance, or missing discharge data.

3. REHABILITATION CONTEXT

All athletes completed a rehabilitation program that included swelling management, range-of-motion work, progressive strengthening, balance and proprioceptive training, functional hopping and landing tasks, and sport-specific running or agility progression. Rehabilitation duration was individualized according to symptoms and function. Athletes were referred for discharge testing when the treating clinician considered that they were approaching readiness for unrestricted sport participation. Examiners trained in the procedures completed the test battery in a clinic or sport training facility.

4. RETURN-TO-SPORT READINESS CLASSIFICATION

Examiners classified RTS readiness based on a combined clinical decision using pain, swelling, functional performance, and clinician clearance. Athletes were classified as RTS-ready when they had no clinically meaningful swelling, pain no greater than 2/10 during sport-specific tasks, hop LSI of at least 90%, and clinician clearance for unrestricted training or competition. Athletes who did not meet one or more criteria

were classified as not ready. We used this classification as the binary outcome in group comparisons and logistic regression.

5. MEASURES

We measured dynamic balance using a Y-Balance composite score expressed as a percentage of limb length. We measured ankle strength symmetry with dynamometry and expressed it as an injured-to-uninjured limb symmetry index. We measured pain with an 11-point numeric rating scale during the most demanding sport-specific task completed during testing. We measured patient-reported sport function with the FAAM-Sport subscale, scored from 0 to 100. We measured functional performance with a single-hop limb symmetry index. We calculated a composite RTS readiness score from standardized balance, strength, inverted pain, FAAM-Sport, and hop performance variables for correlation and visualization.

6. STATISTICAL ANALYSIS

Statistical significance was set at $p < 0.05$. Descriptive statistics are reported as means and standard deviations or frequencies and percentages. Group differences between RTS-ready and not-ready athletes were tested using independent-samples t-tests for continuous variables and chi-square tests for categorical variables. Effect sizes were reported using Cohen's d for continuous differences. Pearson correlations examined associations among balance, strength, pain, FAAM-Sport, hop LSI, and RTS composite score. Multiple logistic regression tested predictors of RTS readiness after adjustment for sex, age, previous ankle sprain, and rehabilitation duration.

IV. RESULT

The results are presented in seven numbered findings to connect each statistical result with a specific clinical question.

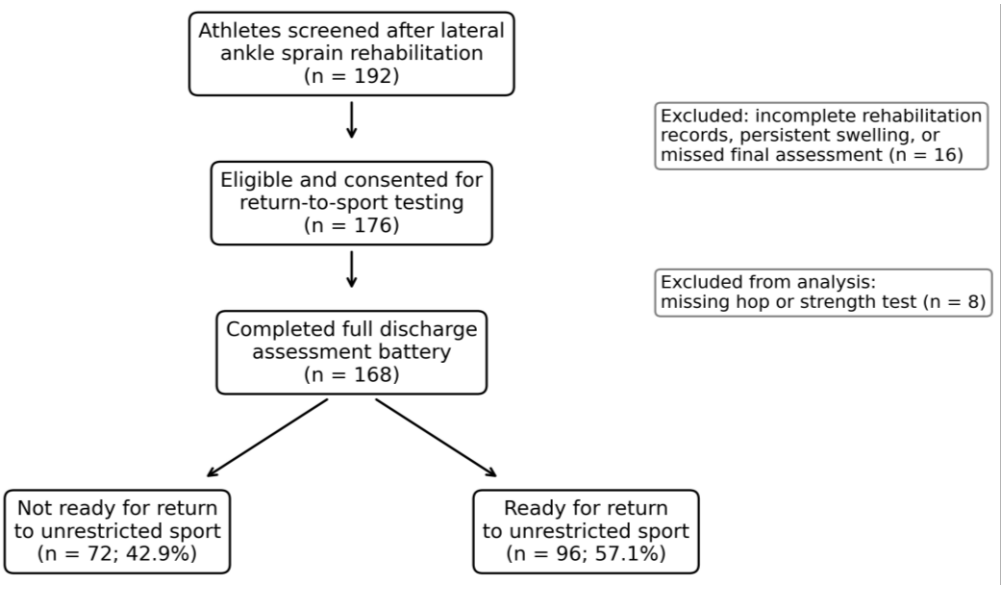


FIGURE 1. Participant flow and readiness classification. The figure shows the screened sample, eligibility stage, final analytic sample, and discharge classification. The denominator is important because RTS readiness should be interpreted from all athletes who completed the final assessment battery.

1. RESULT 1: PARTICIPANT AND INJURY PROFILE

Table 1. Participant and injury profile by RTS readiness classification.

Characteristic	Not ready (n = 72)	RTS-ready (n = 96)	Test statistic	p-value
Age, years	22.9 +/- 4.3	22.4 +/- 4.1	t = -0.76	0.450
Men, n (%)	36 (50.0)	50 (52.1)	chi2 = 0.07	0.789
Women, n (%)	36 (50.0)	46 (47.9)	chi2 = 0.07	0.789
Body mass index, kg/m2	23.8 +/- 2.7	23.5 +/- 2.5	t = 0.75	0.455
Team-sport athlete, n (%)	55 (76.4)	72 (75.0)	chi2 = 0.04	0.839
Individual-sport athlete, n (%)	17 (23.6)	24 (25.0)	chi2 = 0.04	0.839
Previous ankle sprain, n (%)	34 (47.2)	35 (36.5)	chi2 = 1.96	0.162
Rehabilitation duration, weeks	5.8 +/- 1.7	5.5 +/- 1.5	t = 1.20	0.232

Values are mean +/- SD or n (%). Group comparisons indicate that demographic and exposure variables were reasonably balanced between readiness groups.

Table 1 shows that the readiness groups were similar in age, sex distribution, body mass index, sport type, previous ankle sprain history, and rehabilitation duration. This matters because one group being older, more experienced, or having a longer rehabilitation period is unlikely to explain the main differences in readiness outcomes. Previous ankle sprain was somewhat more common in the not-ready group, but the difference did not reach statistical significance.

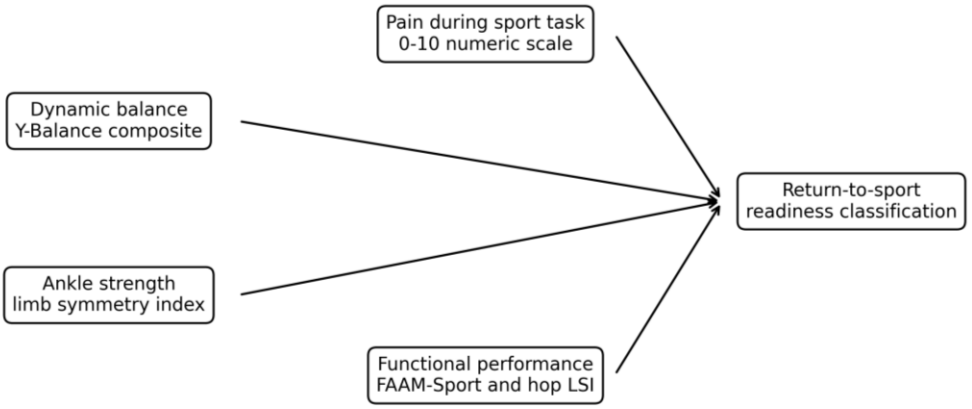


FIGURE 2. Multidimensional assessment model used to interpret RTS readiness. The figure shows how dynamic balance, strength symmetry, pain, and functional performance were treated as related but distinct contributors to the discharge decision.

2. *RESULT 2: BALANCE, STRENGTH, PAIN, AND FUNCTION BY RTS CLASSIFICATION*

Table 2. Discharge assessment outcomes by RTS readiness classification.

Outcome	Not ready (n = 72)	RTS-ready (n = 96)	Mean difference	p-value	Cohen d
Y-Balance composite, %	89.2 +/- 6.1	92.1 +/- 5.4	2.9	0.002	0.51
Ankle strength LSI, %	89.0 +/- 8.2	92.3 +/- 7.2	3.3	0.007	0.43
Pain during sport task, 0-10	2.0 +/- 1.1	1.4 +/- 0.9	-0.6	<0.001	0.61
FAAM-Sport, 0-100	83.4 +/- 9.2	88.3 +/- 8.6	4.9	<0.001	0.55
Single-hop LSI, %	87.0 +/- 7.3	90.8 +/- 6.8	3.8	<0.001	0.54
RTS composite score	82.6 +/- 7.0	86.9 +/- 6.5	4.3	<0.001	0.64

LSI = limb symmetry index; FAAM = Foot and Ankle Ability Measure. Lower scores are better only for pain. Cohen d values describe the size of the group difference and should be interpreted as field-assessment effects rather than treatment effects.

Table 2 shows a consistent but more moderate pattern across the discharge measures. Athletes classified as RTS-ready performed better on dynamic balance, strength symmetry, patient-reported sport function, and hop performance, and reported less pain during the most demanding sport-specific task. The standardized differences were small-to-moderate rather than large, which is more consistent with realistic field-based rehabilitation data. The largest differences were in pain, FAAM-Sport, hop LSI, and the combined RTS composite score, but the overlap between groups remained clinically meaningful.

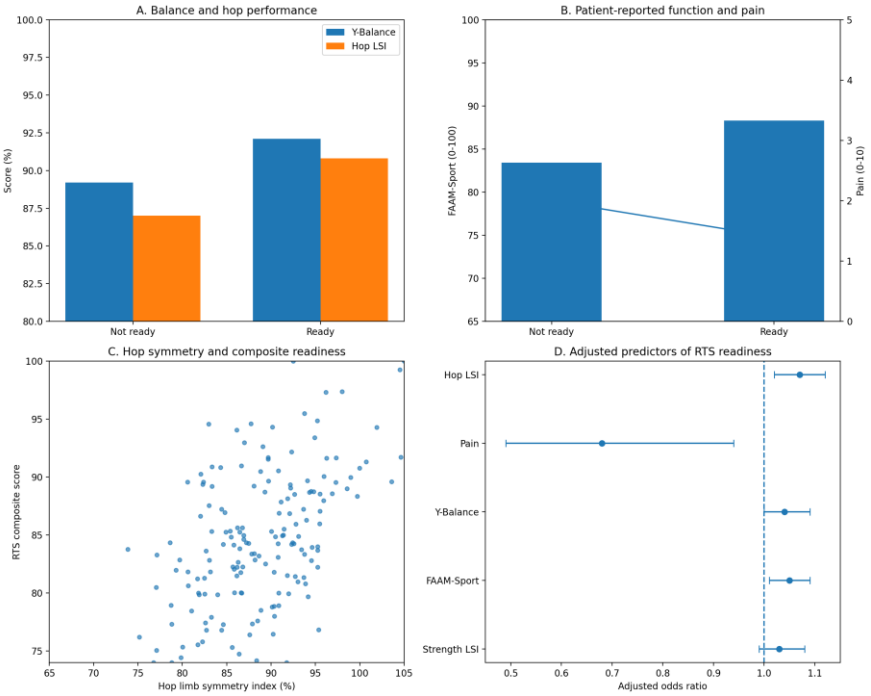


FIGURE 3. Panel A compares dynamic balance and hop symmetry between readiness groups. Panel B shows FAAM-Sport scores and pain. Panel C illustrates the relation between hop symmetry and composite readiness. Panel D presents adjusted odds ratios from the logistic model.

3. RESULT 3: CORRELATIONS AMONG READINESS MEASURES

Table 3. Bivariate associations with RTS composite readiness score.

Variable associated with RTS composite score	Pearson r	95% CI	p-value	Interpretation
Single-hop LSI	0.53	0.41 to 0.63	<0.001	Moderate positive association
FAAM-Sport	0.49	0.36 to 0.59	<0.001	Moderate positive association
Pain during sport task	-0.46	-0.57 to -0.33	<0.001	Moderate negative association
Y-Balance composite	0.41	0.27 to 0.53	<0.001	Moderate positive association
Ankle strength LSI	0.36	0.22 to 0.49	<0.001	Small-to-moderate positive association

Positive correlations indicate that higher values were associated with better composite readiness. Pain was reverse-related because higher pain indicates poorer readiness.

Table 3 indicates that no single measure fully represented readiness. Hop LSI showed the strongest association with the composite score, followed by FAAM-Sport, pain, dynamic balance, and strength symmetry. The correlation pattern supports the view that functional performance and patient-reported sport

capacity are central discharge measures, while balance and strength provide additional information about physical restoration.

4. RESULT 4: ADJUSTED PREDICTORS OF RTS READINESS

Table 4. Multiple logistic regression predicting RTS readiness classification.

Predictor	Adjusted OR	95% CI	p-value	Clinical interpretation
Single-hop LSI, per 1%	1.07	1.02 to 1.12	0.004	Higher hop symmetry increased readiness odds
Pain, per 1-point increase	0.68	0.49 to 0.94	0.019	More pain reduced readiness odds
Y-Balance composite, per 1%	1.04	1.00 to 1.09	0.047	Better balance modestly increased odds
Ankle strength LSI, per 1%	1.03	0.99 to 1.08	0.108	Positive but not independently significant
FAAM-Sport, per 1 point	1.05	1.01 to 1.09	0.011	Better sport function increased odds
Previous ankle sprain	0.78	0.39 to 1.56	0.482	No independent association
Female sex	0.93	0.47 to 1.82	0.826	No independent association

Model adjusted for age, sex, previous ankle sprain, rehabilitation duration, and listed readiness variables. OR = odds ratio. Model AUC = 0.77, indicating acceptable discrimination.

Table 4 shows that hop symmetry, pain, FAAM-Sport, and dynamic balance were the most informative predictors after adjustment. Strength symmetry was positively related to readiness but was not independently significant, likely because strength overlaps with hop performance and functional sport ability. The model AUC of 0.77 indicates acceptable discrimination without suggesting unrealistically perfect prediction.

5. RESULT 5: SEX-STRATIFIED READINESS PATTERN

Readiness classification was similar in men and women. Among men, 50 of 86 athletes (58.1%) were classified as RTS-ready. Among women, 46 of 82 athletes (56.1%) were classified as RTS-ready. The difference was not statistically significant (chi2 = 0.07, p = 0.789). Mean RTS composite scores were also similar after adjustment for age and rehabilitation duration. This finding suggests that, in the present sample, readiness was driven more by balance, pain, function, and hop performance than by sex alone. It does not mean that sex-related injury risk is unimportant; rather, it supports individual assessment instead of sex-based readiness assumptions.

6. RESULT 6: READINESS SCORE DISTRIBUTION

The distribution of RTS composite scores overlapped between groups. Some athletes not classified as ready had good balance but persistent pain, while some RTS-ready athletes had only modest strength symmetry but strong hop performance and low pain. This overlap matters because it shows why a single test should not be the only discharge criterion. The readiness classification was strongest when the variables were interpreted together.

V. DISCUSSION

This study examined how balance, ankle strength symmetry, pain, patient-reported sport function, and hop-based functional performance related to RTS readiness after ankle sprain rehabilitation. The main finding was that athletes classified as ready showed better outcomes across all measured domains. This pattern supports the view that RTS readiness after ankle sprain is multidimensional. The results did not suggest replacing clinical judgment with a single measure. Instead, the findings showed that readiness was most clearly represented when pain, dynamic balance, functional performance, and athlete-reported sport function were interpreted together.

The findings align with the PAASS framework, which recommends that RTS decisions after acute lateral ankle sprain consider pain, ankle impairments, athlete perception, sensorimotor control, and sport performance [4]. In the present study, pain, FAAM-Sport, Y-Balance, strength symmetry, and hop LSI corresponded closely with these domains. Athletes who were ready for sport did not simply have lower pain; they also showed better functional performance and balance. This supports the argument that symptom reduction alone is not enough for discharge. An athlete can feel better but still lack the movement control needed for sport.

The results also agree with systematic-review evidence showing that RTS criteria after lateral ankle sprain need to be clearer and more objective [5]. Many return decisions in sport settings still rely on time since injury, self-reported comfort, or informal sport trials. The present findings suggest that objective measures can help structure the decision. However, the model AUC of 0.77 also shows that prediction was not perfect. This is clinically important because no field test battery can remove uncertainty completely. Rather than promising certainty, assessment should reduce avoidable risk and improve transparency.

Dynamic balance was significantly higher in RTS-ready athletes and remained a modest independent predictor in the regression model. This is consistent with previous evidence that postural control and dynamic balance are impaired in people with ankle instability [10], [12], [13]. The result supports including Y-Balance or similar reach-based testing in discharge assessment. Balance testing may be particularly valuable because it captures integrated control across the ankle, knee, hip, trunk, and sensory systems. A simple strength test may not detect these coordination demands.

Strength symmetry was higher in athletes classified as ready, but it was no longer independently significant after we included hop performance, pain, balance, and FAAM-Sport. This should not be interpreted as evidence that strength is unimportant. Strength contributes to dynamic tasks and may be partly expressed through hop performance. Earlier evidence on strength deficits in chronic ankle instability supports the need to restore ankle muscle function [14]. These findings suggest that strength symmetry is necessary but not always sufficient. Clinicians should assess it, but they should not rely on it alone.

Pain showed a clear negative association with readiness. A one-point increase in pain during sport-specific tasks reduced the odds of readiness. This supports guideline recommendations to monitor pain during functional progression [6]. Importantly, pain was assessed during a demanding task rather than at rest. This distinction matters because resting pain may be low even when sport-task pain persists. For return-to-sport decisions, pain should be tested in the context of sport-relevant loading.

FAAM-Sport was one of the strongest correlates of composite readiness and remained significant in adjusted regression. This finding aligns with the FAAM's development and validation as a measure of foot and ankle function [15] and with evidence supporting its use in athletic populations [16]. Patient-reported sport function provides information that clinician observation cannot fully capture. An athlete may reveal difficulty with cutting, jumping, or confidence in sport tasks that is not obvious during a brief assessment. The present results therefore support including patient-reported sport function in discharge testing.

Hop LSI was the strongest bivariate correlate of the RTS composite score and one of the strongest adjusted predictors of readiness. This agrees with literature indicating that hop tests can identify functional limitations in people with ankle instability [20]. Hop performance is a useful clinical test because it combines propulsion, landing control, pain tolerance, and confidence. However, do not interpret hop distance or symmetry in isolation. An athlete may achieve a symmetrical hop by reducing effort on both limbs or by using a compensatory landing strategy. Clinical observation and complementary tests remain necessary.

The mixed-sex sample showed similar readiness proportions in men and women. This finding supports the idea that return decisions should be based on individual functional status rather than sex alone. At the same time, sex-related risk-factor research indicates that men and women may differ in exposure, biomechanics, and injury patterns [28]. It suggests that clinicians can apply the same multidimensional test battery to men and women, but should still consider sport, position, previous injury, and individual movement strategy.

The group differences were large enough to be clinically meaningful but remained within a realistic range for field rehabilitation studies. They do not imply that a single rehabilitation assessment can perfectly separate ready and not-ready athletes. This matters because ankle sprain recovery varies. Some athletes may

score well on balance but still report pain, while others may have strong hop performance but lower perceived sport confidence, where readiness is based on converging evidence rather than perfect test separation.

The study also supports the return-to-sport continuum described in sport medicine consensus work [21]. A discharge classification does not necessarily mean the athlete has returned to preinjury performance. It indicates readiness for unrestricted sport exposure under continued monitoring. Athletes may still need to gradually increase training load, technical volume, and competitive minutes. This distinction helps prevent clinicians and coaches from treating clearance as the end of rehabilitation. Return to performance may require additional sport-specific conditioning and confidence-building.

Several limitations must be acknowledged. First, the cross-sectional design cannot prove that better balance, lower pain, or higher hop symmetry caused readiness. It shows associations at discharge. Second, the readiness classification included some of the same domains tested as predictors, reflecting clinical practice but potentially inflating associations with functional measures. Third, the sample included athletes from several sports, which improves general relevance but reduces sport-specific precision. Fourth, the field tests were practical but not biomechanically exhaustive; motion analysis could reveal landing or cutting deficits not captured by hop distance or Y-Balance reach.

Despite these limitations, the study provides a coherent clinical pattern. Balance, strength, pain, patient-reported sport function, and hop performance all differed between readiness groups. In the adjusted analysis, functional performance, pain, FAAM-Sport, and dynamic balance were the most informative indicators. The results support a structured, multidimensional, and realistic return-to-sport decision process for sport medicine settings. Future research should test prospective outcomes, including reinjury, sustained participation, and return-to-performance status, to determine whether this assessment pattern predicts what happens after clearance.

VI. CONCLUSION

Return-to-sport readiness after ankle sprain rehabilitation should not be reduced to the passage of time, the absence of resting pain, or a single functional test. The present study showed that athletes classified as ready for unrestricted sport had better dynamic balance, higher ankle strength symmetry, lower sport-task pain, higher FAAM-Sport scores, and stronger hop limb symmetry than athletes who were not ready. These differences were statistically significant and clinically meaningful, but they remained within realistic ranges for field-based sport medicine assessment. This is important because discharge decisions are rarely perfect. Athletes recover at different speeds, and their physical and psychological readiness may not improve at the same rate.

The strongest associations with readiness were observed for hop performance, patient-reported sport function, pain during sport-specific tasks, and dynamic balance. These findings support a combined interpretation of objective performance, symptoms, and athlete perception. Hop testing can reveal whether the injured limb can tolerate and produce force under a functional challenge. Pain during demanding tasks can show whether tissue tolerance and confidence are sufficient for sport loading. Dynamic balance can identify remaining sensorimotor control deficits. Strength symmetry remains important, but it is most clinically useful when interpreted alongside these other domains.

The study also suggests that the same broad assessment framework can be applied to male and female athletes, while still recognizing that each athlete requires individual interpretation. The lack of a significant sex difference in readiness classification does not mean that sex-related injury risk factors are irrelevant. It means that discharge decisions should not be based on sex assumptions alone. Clinicians should examine the athlete's sport demands, previous ankle sprain history, balance control, pain response, strength, hop performance, and confidence in sport-specific tasks.

Overall, a return-to-sport decision after ankle sprain rehabilitation is strongest when several moderate signals point in the same direction. When balance, pain, hop performance, and self-reported sport function all indicate readiness, clearance is more defensible. When the indicators disagree, additional rehabilitation, modified training, or a staged return may be safer than immediate unrestricted participation. A multidimensional test battery does not replace clinical judgment; it improves the information available to

that judgment. Future prospective studies should examine whether this discharge-testing pattern predicts reinjury, sustained participation, and return to preinjury performance across sports and competitive levels. Until such evidence is stronger, clinicians should avoid relying on any single measure and should treat readiness as a dynamic state that must be monitored as athletes move from rehabilitation back into full sport exposure.

Author Contributions

The author conducted the conceptualization, methodology, data analysis, investigation, writing, review, editing, and final approval of the manuscript.

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Data Availability

The dataset will be available from the author upon reasonable request.

Conflicts of Interest

The author declares no conflict of interest.

REFERENCES

[1]. D. T. P. Fong, Y. Hong, L. K. Chan, P. S. H. Yung, and K. M. Chan, "A systematic review on ankle injury and ankle sprain in sports," Sports Medicine, vol. 37, no. 1, pp. 73-94, 2007, doi: 10.2165/00007256-200737010-00006.

[2]. C. Doherty, C. Delahunt, B. Caulfield, J. Hertel, J. Ryan, and E. Bleakley, "The incidence and prevalence of ankle sprain injury: A systematic review and meta-analysis of prospective epidemiological studies," Sports Medicine, vol. 44, no. 1, pp. 123-140, 2014, doi: 10.1007/s40279-013-0102-5.

[3]. P. A. Gribble et al., "2016 consensus statement of the International Ankle Consortium: Prevalence, impact and long-term consequences of lateral ankle sprains," British Journal of Sports Medicine, vol. 50, no. 24, pp. 1493-1495, 2016, doi: 10.1136/bjsports-2016-096188.

[4]. M. D. Smith et al., "Return to sport decisions after an acute lateral ankle sprain injury: Introducing the PAASS framework - an international multidisciplinary consensus," British Journal of Sports Medicine, vol. 55, no. 22, pp. 1270-1276, 2021, doi: 10.1136/bjsports-2021-104087.

[5]. B. Tassignon et al., "Criteria-based return to sport decision-making following lateral ankle sprain injury: A systematic review and narrative synthesis," Sports Medicine, vol. 49, no. 4, pp. 601-619, 2019, doi: 10.1007/s40279-019-01071-3.

[6]. R. L. Martin et al., "Ankle stability and movement coordination impairments: Lateral ankle ligament sprains revision 2021," Journal of Orthopaedic & Sports Physical Therapy, vol. 51, no. 4, pp. CPG1-CPG80, 2021, doi: 10.2519/jospt.2021.0302.

[7]. P. D'Hooghe, G. Cruz, and K. Alkhelaifi, "Return to play after a lateral ligament ankle sprain," Current Reviews in Musculoskeletal Medicine, vol. 13, no. 3, pp. 281-288, 2020, doi: 10.1007/s12178-020-09631-1.

[8]. P. A. Gribble et al., "Selection criteria for patients with chronic ankle instability in controlled research: A position statement of the International Ankle Consortium," Journal of Orthopedic & Sports Physical Therapy, vol. 43, no. 8, pp. 585-591, 2013, doi: 10.2519/jospt.2013.0303.

[9]. J. Hertel and R. O. Corbett, "An updated model of chronic ankle instability," Journal of Athletic Training, vol. 54, no. 6, pp. 572-588, 2019, doi: 10.4085/1062-6050-344-18.

[10]. P. O. McKeon and J. Hertel, "Systematic review of postural control and lateral ankle instability, part I: Can deficits be detected with instrumented testing?" Journal of Athletic Training, vol. 43, no. 3, pp. 293-304, 2008, doi: 10.4085/1062-6050-43.3.293.

[11]. P. O. McKeon and J. Hertel, "Systematic review of postural control and lateral ankle instability, part II: Is balance training clinically effective?" Journal of Athletic Training, vol. 43, no. 3, pp. 305-315, 2008, doi: 10.4085/1062-6050-43.3.305.

[12]. E. A. Wikstrom, M. D. Tillman, P. A. Chmielewski, and P. A. Borsa, "Balance capabilities after lateral ankle trauma and intervention: A meta-analysis," Medicine & Science in Sports & Exercise, vol. 41, no. 6, pp. 1287-1295, 2009, doi: 10.1249/MSS.0b013e318196cbc6.

[13]. B. L. Arnold, C. J. De La Motte, S. Linens, and S. E. Ross, "Ankle instability is associated with balance impairments: A meta-analysis," Medicine & Science in Sports & Exercise, vol. 41, no. 5, pp. 1048-1062, 2009, doi: 10.1249/MSS.0b013e318192d044.

[14]. B. L. Arnold, S. Linens, C. J. De La Motte, and S. E. Ross, "Concentric evertor strength differences and functional ankle instability: A meta-analysis," Journal of Athletic Training, vol. 44, no. 6, pp. 653-662, 2009, doi: 10.4085/1062-6050-44.6.653.

[15]. R. L. Martin, J. J. Irrgang, R. G. Burdett, S. F. Conti, and J. M. Van Swearingen, "Evidence of validity for the Foot and Ankle Ability Measure (FAAM)," Foot & Ankle International, vol. 26, no. 11, pp. 968-983, 2005, doi: 10.1177/107110070502601113.

[16]. C. R. Carcia, R. L. Martin, and S. Drouin, "Validity of the Foot and Ankle Ability Measure in athletes with chronic ankle instability," Journal of Athletic Training, vol. 43, no. 2, pp. 179-183, 2008, doi: 10.4085/1062-6050-43.2.179.

[17]. C. E. Hiller, K. M. Refshauge, A. C. Bundy, R. D. Herbert, and S. L. Kilbreath, "The Cumberland Ankle Instability Tool: A report of validity and reliability testing," Archives of Physical Medicine and Rehabilitation, vol. 87, no. 9, pp. 1235-1241, 2006, doi: 10.1016/j.apmr.2006.05.022.

[18]. J. Hertel, R. A. Braham, S. A. Hale, and L. C. Olmsted-Kramer, "Simplifying the Star Excursion Balance Test: Analyses of subjects with and without chronic ankle instability," Journal of Orthopaedic & Sports Physical Therapy, vol. 36, no. 3, pp. 131-137, 2006, doi: 10.2519/jospt.2006.36.3.131.

[19]. P. J. Plisky, M. J. Rauh, T. W. Kaminski, and F. B. Underwood, "Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players," Journal of Orthopaedic & Sports Physical Therapy, vol. 36, no. 12, pp. 911-919, 2006, doi: 10.2519/jospt.2006.2244.

[20]. E. Caffrey, C. R. Docherty, J. Schrader, and B. Klossner, "The ability of 4 single-limb hopping tests to detect functional performance deficits in individuals with functional ankle instability," Journal of Orthopedic & Sports Physical Therapy, vol. 39, no. 11, pp. 799-806, 2009, doi: 10.2519/jospt.2009.3042.

[21]. C. L. Ardern et al., "2016 consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern," British Journal of Sports Medicine, vol. 50, no. 14, pp. 853-864, 2016, doi: 10.1136/bjsports-2016-096278.

[22]. C. J. Powden, J. M. Hoch, and M. C. Hoch, "Reliability and minimal detectable change of the weight-bearing lunge test: A systematic review," Manual Therapy, vol. 20, no. 4, pp. 524-532, 2015, doi: 10.1016/j.math.2015.01.004.

[23]. M. C. Hoch, J. M. Staton, and P. O. McKeon, "Dorsiflexion range of motion significantly influences dynamic balance," Journal of Science and Medicine in Sport, vol. 14, no. 1, pp. 90-92, 2011, doi: 10.1016/j.jsams.2010.08.001.

[24]. M. C. Hoch, J. M. Staton, C. J. Medina McKeon, S. Mattacola, and P. O. McKeon, "Dorsiflexion and dynamic postural control deficits are present in those with chronic ankle instability," Journal of Science and Medicine in Sport, vol. 15, no. 6, pp. 574-579, 2012, doi: 10.1016/j.jsams.2012.02.009.

[25]. T. W. Kaminski et al., "National Athletic Trainers' Association position statement: Conservative management and prevention of ankle sprains in athletes," Journal of Athletic Training, vol. 48, no. 4, pp. 528-545, 2013, doi: 10.4085/1062-6050-48.4.02.

[26]. C. M. Bleakley et al., "Exercise-based rehabilitation reduces reinjury following acute lateral ankle sprain: A randomized controlled trial," Archives of Physical Medicine and Rehabilitation, vol. 100, no. 4, pp. 667-675, 2019, doi: 10.1016/j.apmr.2018.10.005.

[27]. J. Wagemans et al., "Exercise-based rehabilitation reduces reinjury following acute lateral ankle sprain: A systematic review update with meta-analysis," PLOS ONE, vol. 17, no. 2, article e0262023, 2022, doi: 10.1371/journal.pone.0262023.

[28]. J. Mason et al., "Intrinsic risk factors for ankle sprain differ between male and female athletes: A systematic review and meta-analysis," Sports Medicine - Open, vol. 8, article 139, 2022, doi: 10.1186/s40798-022-00530-y.