THE IMPACT OF HAMSTRING INJURIES ON SEASON BEST PERFORMANCE AT THE RETURN-TO-SPORT PHASE: A SURVEY OF TRACK RUNNERS IN HIGH-ALTITUDE TRAINING CAMPS IN KENYA

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The Impact of Hamstring Injuries on Season Best Performance at the Return-To-Sport Phase: A Survey of Track Runners in High-Altitude Training Camps in Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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This Thesis has been submitted for examination with our approval as the University Supervisors

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DEDICATION

I dedicate this work to my beloved husband Liston Koskei and my three daughters: Ruth Chepkoech, Louise Chelangat, Becky Chemutai.

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May God bless you all!

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ACRONYMS AND ABBREVIATIONS

AKET	Active Knee Extension Test
BF	Biceps Femoris
CKC	Closed Kinetic Chain
CON	Concentric
ECC	Eccentric
ESH	Elongation Stress on Hamstring
HI	Hamstring Injury
HR	Heart Rate
HSI	Hamstring Strain Injuries
ISOM	Isometric
MTJ	Myotendinous Junction
NHE	Nordic Hamstring Exercises
OKC	Open Kinetic Chain
ROM	Range of Motion
RTP	Return to Play
RTS	Return to Sports
SLR	Straight Leg Raise
SM	Semimembranosus
ST	Semitendinosus

DEFINITION OF OPERATIONAL TERMS

Hamstring This is one of the three posterior muscles of the thigh between the hip and the knee. The muscle originates from the ischial tuberosity and is inserted over the knee at the tibia and fibula bones. Its nerve supply is the tibial branch of the sciatic nerve. Its main function is knee flexion and hip extension

Hamstring injury Hamstring injury is a strain or a tear to the tendon or large muscle at the back of the thigh. It is a common injury in athletes and can occur in different severities. The 3 grades of hamstring injury are: grade 1(a mild muscle pull or strain); grade 2(a partial muscle tear); grade 3(a complete muscle tear

Return to sports This is the period during which an athlete can go back to his/her previous sport following a period of rehabilitation. It is suggested that the criteria for return to sport can be characterized by pain free clinical evaluation, minimal range of motion and strength deficits, symmetrical hoping performance successful completion of a progressive rehabilitation program and sport specific functional field testing, attained pre injury sprinting speed, no apprehensions during full effort sport specific movements or full speed sprints, ballistic hamstring test. The athlete has returned to his or her defined sport, but is not performing at his or her desired performance level. Some athletes may be satisfied with reaching this stage, and this can represent successful RTS for that individual

Return to performance This is the point the athlete has gradually returns to his or her defined sport and is performing at or above his or her pre-injury level. For some athletes this stage may be characterized by personal best performance or expected personal growth as it relates to performance

ABSTRACT

Background: Hamstring injuries are prevalent among runners, often resulting from sprinting techniques during acceleration. Such injuries frequently force athletes out of competition, impacting their performance and revenue. The rehabilitation period varies depending on the injury's nature; muscle bulk injuries generally heal faster than those involving the tendon. This study aimed to evaluate the impact of hamstring injuries on track runners' performance during the return-to-sport phase of rehabilitation in high-altitude regions of Western Kenya.Design and Method: The study was conducted in accredited training camps in Western Kenya, with ethical approval from the JKUAT Ethics and Review Committee and NACOSTI. The Functional Assessment Scale for Hamstring Injuries (FASH) was used for injury screening, and an observational checklist recorded conventional rehabilitation strategies. A desk review assessed athletes' performance before injury. Post-rehabilitation performance data was collected and analyzed using SPSS version 25. Moderator effect analysis and multi-linear regression were conducted to determine the impact of injury on performance. Results: Out of 415 athletes screened, 221 (30.3%) had hamstring injuries. Among these, 72 (32.6%) experienced severe pain during static stretching, 71 (32.1%) during 30-meter sprints, and 69 (31.2%) during full weight-bearing lunges. Severe injuries were more common in males (93.8%, n=61) compared to females, although no significant relationship between gender and injury severity was found ($p > .05$). A dependent t-test revealed significant differences in performance times before and after injury, with average completion times increasing from 0:38:33.18 to 0:40:04.16, indicating a 1:30.97 increase ($t (220) = -6.747$, $p < .001$). Pearson correlation analysis showed a significant positive relationship between pain during sprinting, discomfort during partial and full weight-bearing lunges, and the time difference pre- and post-injury ($p < .05$). Regression analysis indicated that 4.8% of the variation in performance time after injury could be attributed to the injury severity ($R^2 = .048$, $F (1, 117) = 5.85$, $p = .017$). The severity of the injury significantly predicted performance time on return to sport ($\beta = .048$, $t = 2.419$, $p = .017$). Deviations in performance times post-rehabilitation included 24 seconds in 800m, 21 seconds in 1500m, 31.7 seconds in 3000m, 45 seconds in 5000m, 4 minutes in 10000m, 5 minutes in half-marathon, and 16 minutes in the 42km marathon. Conclusion: The study highlights the need for a standardized treatment protocol for hamstring injuries in Kenya. Developing such protocols will help sports physiotherapists and support staff provide consistent and effective rehabilitation, improving athletes' return-to-sport outcomes. Further research is recommended to explore the prevalence of hamstring injuries in Kenya and to refine rehabilitation practices.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Hamstring injuries(HI) account for 37% of all sports injuries and 25% of athletes' absenteeism in games globally (Nih, 2015). Hamstring strain injuries (HSI) account for over 1/3 of all muscle injuries in sports and are the most prevalent injuries involving high-speed sprinting (Duhig et al., 2016; Guillodo et al., 2014). Researchers have classified risk factors of hamstring injury into: non-modifiable and modifiable risk factors (Opar et al., 2021). Some sports such as track that involve lengthening of hamstring muscle have a higher risk than court sports(C. Askling, 2018). According to Askling the risk of injury is more observed in pre-season and competition and not during training. Running and sprinting are activities more likely to cause hamstring injuries affecting male more than female athletes (Opar et al., 2022). A study conducted in the United Kingdom (UK) by Woods *et al*. (2018) amongst 91 professional athletic clubs in two seasons, found that HSI accounted for 12% of all the injuries, about 53% of these injuries were HSIs involving the biceps femoris muscle(Woods et al., 2020).

The period of treatment of HSIs and the number of missed competitions result in a substantial cost (Erickson & Sherry, 2017). HSI's result in considerable time loss from training and competition, which in turn translate to financial loss and diminished athletic performance. Raysmith and Drew estimated the cost of HSI in excess of 74.4 million in the English athletes clubs during the 2019–2020 seasons(Raysmith& Drew, 2016). Similar estimates for elite Australian athletic teams indicated that HSIs cost approximately $AU 1.5 million in the 2019 season, which represented 1.2% of the salary cap in the Australian division (Opar et al., 2021). In addition to lost time and competition opportunities, the loss of income accrued during the peak seasons affect athletes' physically and mentally (Raysmith& Drew, 2017).

This impact of HI and their potential risk factors have motivated continuing research on hamstring injuries (Opar, Williams & Shield, 2019). For example, (Opar et al., 2012)observed that player performance was significantly reduced at return-to-sport (RTS) following rehabilitation. Further, previous studies have not only surveyed on the incidence of HSIs but also on their relapse. Relapse of Hamstring strain injuries (HSIs) is common in approximately 1/3 of the cases within the first two weeks after return-to-sports (RTS)(Erickson & Sherry, 2017). In over 13 seasons of athletic cycle , Van *et al* observed that 27% of all recurrent injuries were Hamstring strain injuries .(Van Mechelen et al., 2022). Further, in a study conducted in Melbourne amongst professional athletes in the Australian athletic division found that the rate of relapse of hamstring injuries accounted for nearly 12% as compared to 7% of all other injuries(Clark & Hons, 2008).It is not clear from previous studies whether the rate of relapse is due to intrinsic factors or extrinsic factors or due to poor rehabilitation strategies(Martinez-martinez, Idoate & Mendez-villanueva, 2017).However, the high rate of relapse may be related to a combination of factors including: ineffective rehabilitation and inadequate criteria for return-to-sport(Nih, 2018).

Whereas, the decision on RTS has legal, health and economic implications, no consensus or standard criteria exists in literature globally (Valle et al., 2016). In current practice the guiding principles on RTS are pain resolution, normal strength, subjective feeling of full recovery as reported by the athlete, normal flexibility and achievement of sport specific tests (Ardern et al., 2016). In addition, the relationship between the site of injury and the distance to the ischial tuberosity determine the duration it takes to heal and RTS (Brukner, 2020).

On the other hand, high sprinting sports are a challenge for athletes at RTS phase of rehabilitation thus determining the timing of RTS is even a bigger challenge. Some athletes may return-to-sports immediately while others take long, but may eventually return(Valle et al., 2016). Moreover, scientific knowledge about the injury and the therapeutic options is of paramount importance during designing of rehabilitation protocols(Chakravarthy et al., 2018). Most of these studies have been conducted in developed countries such as Australia (Opar et al., 2020), UK (Duhig et al., 2016)and (USA) (Askling, 2018). However, very few studies have been conducted in low- and medium-income countries more specifically in Africa on athlete's performance at the return-to-sport phase of rehabilitation. In Sub-Saharan Africa more specifically in Kenya, there is little information concerning the effect of hamstring injuries on athlete's performance at the return-to-sport phase of rehabilitation amongst track runners. The process of returning to sport after a hamstring injury is fraught with challenges. Athletes vary significantly in their recovery times, influenced by injury location and healing processes (Brukner, 2020). This inconsistency highlights the need for tailored rehabilitation protocols informed by scientific research (Chakravarthy et al., 2018). While much of the existing literature originates from developed countries, there is a critical gap in understanding HSIs within the context of low- and middle-income nations, particularly in Africa.

In Kenya, and other Sub-Saharan Africa, research on the impact of hamstring injuries on athlete performance at the RTS phase is limited. Prior studies have identified HSIs as the most common injuries among Kenyan runners but did not adequately address their effects on performance (Mbarak et al., 2019; Koech et al., 2021).

This study aims to fill this gap by investigating the impact of hamstring injuries on season-best performance among track runners in high-altitude training camps in Kenya. By understanding these dynamics, the research will contribute valuable insights to improve rehabilitation strategies and performance outcomes for athletes facing hamstring injuries.

Addressing hamstring injuries is crucial for optimizing athlete performance and minimizing economic losses in sports. This study will provide a much-needed focus on the experiences of Kenyan track runners, helping to inform future rehabilitation protocols and enhance the understanding of HIs in low-resource settings.

1.2 Problem Statement

Hamstring injuries are particularly prevalent among runners and are associated with significant costs, both financially and in terms of the time required for recovery (Opar et al., 2012). These injuries not only impose a financial burden but also have considerable psychological impacts on athletes. Additionally, the frequent relapse of hamstring injuries can lead to premature exits from sports careers (Duhig et al., 2016).

There is a notable lack of comprehensive data on athletes' optimal performance during the return-to-sport (RTS) phase following hamstring injury rehabilitation. This gap in information has resulted in the use of rehabilitation strategies that may lack empirical evidence, leading to suboptimal recovery outcomes (Valle et al., 2016). Consequently, sports therapists and rehabilitation professionals often rely on subjective reports from athletes regarding their recovery status, rather than objective performance metrics.

The current situation underscores the necessity for a clearer understanding of how hamstring injuries affect performance during the RTS phase. This is especially critical for track runners in accredited high-altitude training camps in Kenya, where specific challenges related to these conditions may further influence recovery and performance. Establishing the precise impact of hamstring injuries on performance at this critical phase is essential for developing effective, evidence-based rehabilitation protocols and improving overall athlete outcomes.

1.3 Justification

The results of this study would inform the literature gap on the impact of hamstring injuries on track runners in Kenya. The study findings will help to bridge the gaps of information access by clinicians and sports coaches who are directly involved with the athletes. These professionals will develop new knowledge in the sporting field and will in turn use the new knowledge to design evidence-based intervention strategies that have a higher likelihood to improve athletes' performance, prevent relapses and minimize further injuries. Further, the study findings will help to identify training needs for both the clinicians and the coaches who are directly involved with the athletes. The findings of the current study will form baseline data that may be used in developing and modifying policies in sports injuries management in the country.

1.4 Research Questions

1. What is the point prevalence and distribution of hamstring injuries among track runners training at accredited high altitude training camps in Kenya?
2. What is the deviation of athletes' best performance at return-to-sport phase of rehabilitation in accredited high altitude training camps in Kenya?
3. What are the conventional rehabilitation strategies used to rehabilitate hamstring injuries amongst track runners training at accredited high altitude training camps in Kenya?

1.5 Objectives

1.5.1 Broad Objective

To determine the effect of hamstring injuries on athlete's best performance at the return-to-sport phase of rehabilitation amongst track runners training in accredited high altitude training camps in Kenya.

1.5.2 Specific Objectives

1. To determine the point prevalence of hamstring injuries among track runners training in accredited high altitude training camps in Kenya.
2. To determine the post rehabilitation deviation of performance at return-to-sport phase of rehabilitation amongst track runners with Hamstring injuries training in accredited high altitude training camps in Kenya

3. To identify the conventional rehabilitation strategies used to rehabilitate track runners with hamstring injuries training at accredited high-altitude training camps in Kenya

1.6 Conceptual Framework

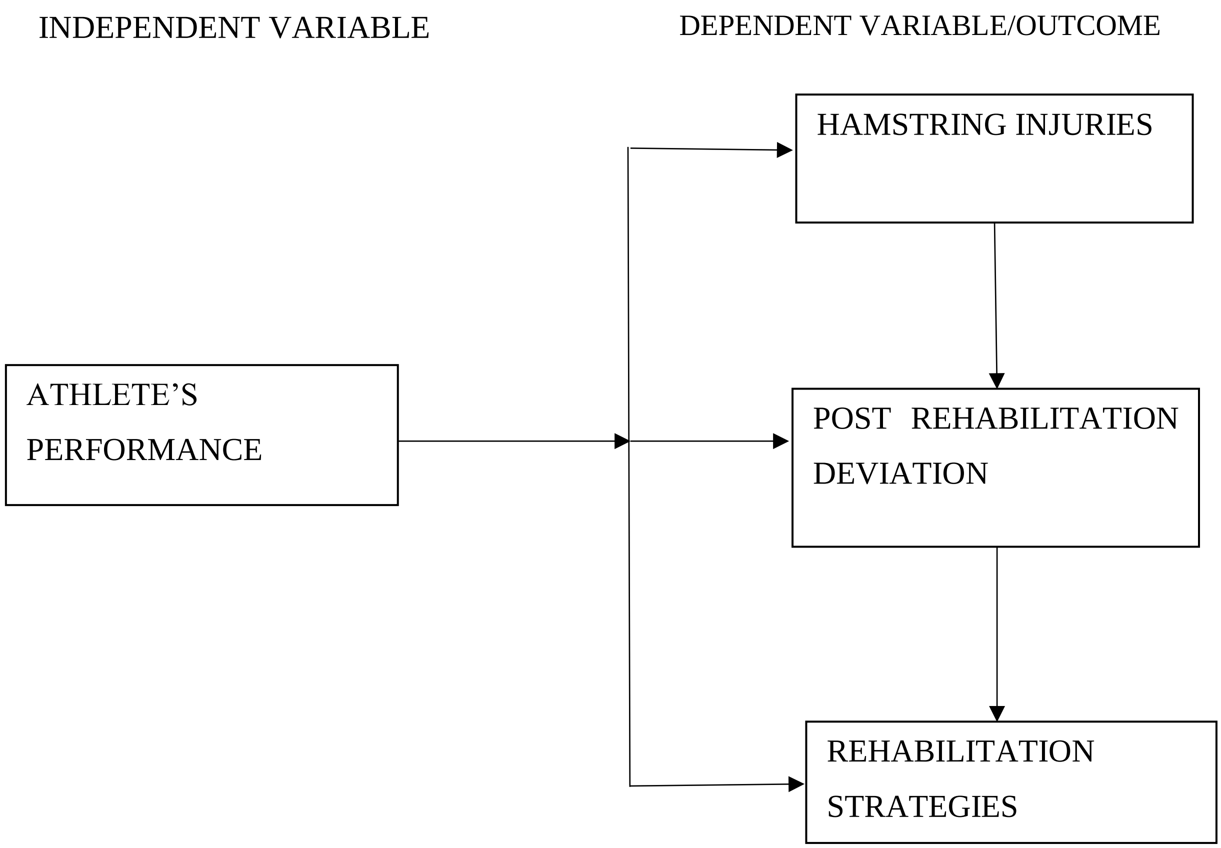

Figure 1.1: Conceptual Framework

CHAPTER TWO

LITERATURE REVIEW

2.1 Prevalence and Causes of Hamstring Injuries

2.1.1 Point Prevalence of Hamstring Injuries

Hamstring injuries are the most common type of muscular injuries representing 37% of all lower limb injuries that occur in elite athletes (Medina, Eirale, Tol & Weir 2017). In a systematic review Erickson and Sherry (2016) found that hamstring injuries were only second to knee injuries among sports injuries. According to findings in Ohio, USA, hamstring injuries are most common in running backs, defensive backs and wide receivers(DeWitt & Vidale, 2019). In soccer, for instance, hamstring injuries were the most prevalent, representing 12% of all injuries recorded from 51 professional soccer teams.

Hamstring Strain Injuries (HSIs) account for 12% of all primary injuries affecting the lower limbs, and have a relapse rate of 32%(Erickson & Sherry, 2020).Dewitt *et al* (2016) noted that the prevalence of HSIs in professional soccer is higher than in sprinters Further, Dewitt *et al* (2016) reported that a high proportion of these injuries occur in sports that require sprinting, kicking, acceleration and/or change of direction including rugby and football. According to Ernlund and Vieira (2021) hamstring injury incidence is estimated at 3-4.1/1000 hours of competition and 0.4–0.5/1000 hours of training. In their study, Ernlund and Vieira (2017) noted that hamstring injuries were the main cause of absence from training and competition with some athletes requiring an average of 16 weeks' time off. Whereas the incidence of HSIs remains high in many sports the incidence of relapse is disparate, that is, at a rate of 11.4% in athletics and between 6% and 12% in rugby, especially during international competitions (Tokutake, Kuramochi, Murata, Enoki & Koto 2018).

In South Africa, a study among field hockey players highlighted significant issues with hamstring injuries, showing a history of strains at 45.5%. The findings also indicated decreased hamstring function (48.5% left, 51.5% right), strength (84% left, 87.9% right), and flexibility (75.8% for both sides). Additionally, hip flexor flexibility was reduced (48.5% left, 39.4% right). Despite these insights, there is a notable lack of comprehensive data on hamstring injuries among athletes across Africa, underscoring the need for further research to better understand and address these prevalent issues.

In Kenya, specifically in Sub-Saharan Africa, research on the impact of hamstring injuries on athlete performance at the RTS phase is limited. Prior studies have identified HSIs as the most common injuries among Kenyan runners but did not adequately address their effects on performance (Mbarak et al., 2019; Koech et al., 2021).

2.1.2 Causes of Hamstring Injuries

It is estimated that one third of all HSIs will recur within two weeks after RTS(Askling et al., 2019). According to Erickson and Sherry (2017) factors contributing to HSIs relapse could be inadequate rehabilitation program, early return to sport or both. (Dewitt *et al* 2020) identified prior hamstring injury as a key predictor for a hamstring re-injury. Further, (Croisier, 2019) posits that hamstring injury is directly related to pre-season hamstring tightness. High relapse of HSIs result in more time loss than in fresh or first-time injuries.

Previous research has identified age, sex and ethnic origin as potential non-modifiable risk factors for HSIs. Further, both intrinsic and extrinsic (also as considered modifiable) risk factors have also been identified including muscle weakness, instability, fatigue, poor flexibility, poor core stability and psychological factors (Schmitt & Tyler, 2020). Additionally, environmental factors (extrinsic factors) such as level of play, field position and insufficient warm up are also known to predispose athletes to HSIs (Schmitt & Tyler, 2016).

There are two types of hamstring injuries recorded in literature: the stretch type and the sprint type (Schmitt & Tyler, 2021). According to Schmitt and Tyler (2019) stretch types of hamstring injury are caused by a slow or sudden uncontrolled stretch and occur most frequently in dancing, gymnastics and water skiing. It is common in the proximal free tendon of the semimembranosus muscle and takes a long to rehabilitate (Waterworth, 2020). The sprint type of hamstring injury occur in explosive running and cutting sports such as soccer, athletics, rugby and field hockey (Croisier, 2021).

A myriad of complications occur after HSIs. In a study at the University of Wisconsin, USA, characterizing hamstring strength and morphology at the time of return-to-sport conducted on 25 athletes with hamstring strain injuries after a controlled rehabilitation program(Sanfilippo et al., 2019) found that there was weakness and atrophy of hamstring at RTS which that was attributable to neuromuscular factors. Additionally, in a study conducted in Doha, Qatar, to evaluate isokinetic outcomes in 52 footballers with hamstring injuries after completing a standardized rehabilitation program, Tol et al. (2014) found that 67% of them had clinically recovered and more than 10% of the players had at least one hamstring isokinetic testing default. This begs the question. What criteria guide decision to return athletes to sports?

2.2 Return to Sport

There is little evidence suggesting valid functional test to determine RTS fitness after hamstring strain injuries (HSIs). According to Schmitt, Tim and McHugh. (2012) the lack of valid functional tests may suggest that the rehabilitation professionals return athletes to sports/competition before full recovery of hamstring muscle. Standardization of RTS with clear indicators for outcomes is lacking (Ardern et al., 2016). However, there is some consensus that athletes can be cleared to return to sports once full range of motion(ROM), strength, and functional abilities (jumping, running, and cutting) can be performed without pain or stiffness(Erickson & Sherry, 2017).

Varying recovery periods have been reported in different studies ranging from an average of 11.3 days to 50 weeks among professional football players (Valle et al., 2016). For example, RTS is generally allowed after 6–9 months following surgical repair after total proximal hamstring ruptures (Ardern et al., 2016).However, timing of RTS of following injury is also partly influenced by psychosocial factors which include fear and apprehension among athletes(Askling et al., 2020). In a study amongst athletes who underwent anterior cruciate ligament reconstruction, conducted in USA, increased fear of movement and re-injury was associated with decreased perceived function in individuals at the final stage of rehabilitation (Sanfilippo et al., 2019). In the same study assessing athletes' readiness to RTS, Sanfillipo, (2015) found that despite passing common clinical strength and flexibility tests, observed that athletes with recent hamstring strain injury had anxiety when performing a ballistic hip motion at the time of RTS testing. Fear or apprehension at the time of RTS may explain the corresponding reduction in strength (Sanfilippo et al., 2016).

2.3 Standard Rehabilitation Strategies

Most recent rehabilitation protocols for HSIs incorporate an objective and subjective criterion of assessment to determine progress between phases (Askling et al., 2021). Rehabilitation combines different strategies such as therapeutic exercises (to work locally on the scar) and look into improving capabilities such as control of the lumbar-pelvic region. However, most protocols that are in use lack consensus on key points like strength evaluation (Valle et al., 2016).Standard rehabilitation guidelines divide rehabilitation into 3 phases, with specific treatment goals and progression criteria for phase advancement and return to sport (Shariff et al., 2018). The rehabilitation focus for phase one is to minimize pain and edema, restoration of normal neuromuscular control at slower speeds, and the prevention of excessive scar formation while protecting the healing fibers from excessive lengthening (Erickson & Sherry, 2017). This phase also consists of range of motion and gait training exercises; it lasts for 6 weeks (Erickson & Sherry, 2017).The second Phase allows for increased intensity of exercise, neuromuscular training at faster speeds and larger amplitudes and the initiation of eccentric resistance training.

In the third Phase, progression to high-speed neuromuscular training and eccentric resistance training in a lengthened position of the hamstring muscle in preparation for return to sport and development of power are key(Erickson & Sherry, 2017). Thus, an effective rehabilitation program is that which promotes muscle and tissue recovery and minimizes risk of re-injury with an ultimate aim of performance improvement after RTS (Heiderscheit et al., 2020). At the return to sports stage of rehabilitation, athletes are expected to restore their season's best performance or exceed. There is lack of information on the effects hamstring injuries on athletes' season's-best performance at the return-to-sports phase of rehabilitation particularly in Kenya. This study seeks to fill this gap by determining the impact of hamstring injuries on athletes' season best performance at return-to-sport phase of rehabilitation amongst track runners in Kenya.

In summary, Kenya, and other Sub-Saharan Africa research on the impact of hamstring injuries on athlete performance at the RTS phase is limited. Prior studies have identified HSIs as the most common injuries among Kenyan runners but did not adequately address their impact on performance (Mbarak et al., 2019; Koech et al., 2021). There is also lack of standardized, valid functional tests to determine readiness for return to sport following hamstring strain injuries (HSIs). While some consensus exists on the importance of full range of motion, strength, and functional abilities without pain, clear, universally accepted indicators for RTS are missing. Although standard rehabilitation strategies for HSIs generally follow a three-phase approach, there is no consensus on key aspects such as strength evaluation. This suggests that while rehabilitation protocols exist, there is a need for standardized guidelines and more research on their effectiveness, particularly regarding specific strength assessments.

There is also insufficient information on how HSIs affect athletes' season-best performance upon return to sport, particularly in Kenya. Understanding how HSIs impact performance and recovery in specific contexts, like track running in Kenya, remains unexplored.

The role of psychosocial factors, such as fear of re-injury and its impact on perceived function and performance during RTS, requires further investigation. Existing studies suggest that these factors may significantly influence recovery and readiness for RTS but are not yet well understood or integrated into rehabilitation protocols.

There is a need for more comprehensive understanding and strategies to address the high relapse rates of HSIs. Factors contributing to re-injury, such as inadequate rehabilitation or early return to sport, need further exploration to develop effective prevention and treatment strategies.

These gaps highlight areas where more research and development are needed to improve the management, rehabilitation and performance outcomes for athletes recovering from hamstring injuries.

CHAPTER THREE

METHODOLOGY

3.1 Study Setting

The study was carried out in all high-altitude accredited camps with athletes training in Kenya. In Kenya-, middle- and long-distance runners, whose interest is to develop endurance capacity, mainly utilize high altitude camps for training hence their selection as study settings. These camps are Nakuru, Keringet, Ole nguruone, Kericho, Kapsabet, Mosoriot, Eldoret, Nyahururu,Litein and Iten.

3.2 Study Design

The study employed a cross-sectional design focused on track runners with hamstring injuries training at accredited high-altitude training camps in Kenya, utilizing quantitative methods (Rindfleisch et al., 2008). This cross-sectional design is appropriate for investigating the prevalence of hamstring injuries and understanding the reported impacts of these injuries over time. Cohort design was used establish the impact of hamstring injuries. Participants were initially screened for hamstring injuries and subsequently monitored to assess their best performance at the return-to-sport phase of rehabilitation. Throughout this period, the rehabilitation strategies utilized were also documented.

3.3 Population and Sampling

3.3.1 Study Population

The study population was track runners with hamstring injuries training accredited high altitude training camps in Kenya

Table3.1 illustrates the estimated number of the athletes according to camp official records.

Table 3:1: Estimated Population of Athletes by Camps

Name of the region	Number of camps	Total number of athletes
Nakuru	3	100
Keringet	2	200
Ole nguruone	1	50
Kericho	4	200
Kapsabet	6	100
Mosoriot	2	60
Eldoret	4	150
Iten	8	300
Total	**30**	**1160**

3.3.1.1 Inclusion Criteria

All track runners reporting injuries occasioned by their engagement in sports and are present at the period of the study. Only those who consented were included.

3.3.1.2 Exclusion Criteria

Track runners with injuries acquired outside sporting activities, including those who were undergoing treatment for sports injuries were excluded. Athletes with uncertain clinical diagnosis and/ or chronic low back pain or sciatica were also excluded.

3.3.2 Sample Size Determination and Sampling Procedure

The recruitment process for this study involved a comprehensive census of all athletes training at accredited high-altitude training camps in Kenya. Initially, all athletes were screened subjectively for complaints of posterior thigh pain. This preliminary screening aimed to identify individuals who might be experiencing symptoms indicative of hamstring injuries.

Once athletes reported posterior thigh pain, they underwent a further assessment to confirm the presence of an actual hamstring injury. This assessment included a detailed evaluation of their symptoms and physical examination to determine the nature and extent of the injury.

A total of 1,160 athletes were targeted for screening, of which 730 underwent assessments. Among these, 415 reported positive responses for posterior thigh pain. Further evaluations confirmed that 221 of these athletes had hamstring injuries. Only the 221 participants with confirmed hamstring injuries were included in the analysis, ensuring that the findings accurately reflect the experiences and performance outcomes of those specifically affected by hamstring injuries.

3.4 Data Collection

The initial assessment of subjective complaints of posterior thigh pain was conducted through a structured interview and questionnaire process. Athletes were approached individually and asked to describe any pain or discomfort they experienced in the posterior thigh region. This involved asking specific questions about the onset, duration, and intensity of their symptoms.

To facilitate this assessment, a standardized questionnaire was utilized, which included items designed to gauge the nature of the pain, including its location, severity, and any activities that exacerbated the discomfort. Athletes were encouraged to provide detailed responses to ensure accurate reporting of their symptoms.

The assessment was structured to ensure consistency across participants, allowing the researchers to effectively identify those who reported posterior thigh pain. This subjective information served as a critical first step in determining which athletes would undergo further evaluation for potential hamstring injuries. Only those with confirmed complaints of posterior thigh pain were subsequently assessed for actual injuries, leading to the recruitment of the final participant cohort for the study.

Data was collected using firstly the functional assessment scale for hamstring injuries (FASH) (Appendix III). The questionnaire comprised of 10 questions. Seven questions used 0 - 10 Visual analogue numerical rating and the remaining three questions used a categorical rating system on an incremental range of values.

Secondly, an observational checklist was used to observe and record the conventional rehabilitation strategies that are being used in the training camps. Observed rehabilitation strategies was compared to standard rehabilitation strategies in the Rehabilitation Protocol for Hamstring Muscle Injuries(Valle et al., 2016).The researcher also reviewed existing records for the purposes of determining the athlete's best performance before hamstring injury and the performance at the return to sport phase of rehabilitation.

3.5 Validity and Reliability

FASH questionnaire was assessed for validity and reliability in Greek speaking patients. Test–retest analysis revealed excellent temporal stability ($p < 0.001$; 95% CI = 0.953–0.993). Spearman's rho for test–retest reliability was $r = 0.841$ ($p < 0.001$). The standard error of measurement was 0.78, and the calculated minimal detectable change was 2.16. Internal consistency was excellent with a Cronbach α of 0.983 for the first and 0.917 for the second FASH-G assessment.

3.6 Pilot Study

The functional assessment scale for hamstring injuries (FASH) was subjected to a test-retest reliability test at the Rongai Athletics club in Kajiado County. The two sets of data were analyzed through the Kappa Cohens reliability test of SPSS. Further, Physiotherapists with a minimum qualification of a Diploma working in the camp was requested to give feedback on the friendliness of the tool for execution by other Physiotherapists. Their feedback was incorporated in the tool prior to actual data collection.

3.7 Data Analysis

The collected data was entered in statistical package for social sciences SPSS version 25. Descriptive statistics was calculated and compared between the data sets and errors corrected by re-entering data from the data collection instruments. A moderator effect analysis for the variables was conducted followed by a multi-linear regression analysis to establish the effect of injury on performance. Descriptive and inferential statistics were presented in tables and graphs.

The FASH questionnaire were analyzed as per the author's instructions. These are such that the best score is 100 and worst score is 0. FASH highest score is 100 meaning normal, while lowest score of 0 is interpreted as complete disability and no normal physical functioning.

3.8 Ethical Consideration

The researcher sough authority to conduct the study from NACOSTI after gaining approval from JKUAT Ethics Review Committee. Permission to access athletes was sought from the Athletic Kenya Federation. The researcher trained two research assistants in preparation for data collection. These were physiotherapists with a minimum of a diploma and experienced in sports physiotherapy. The research assistants were inducted on the aims and objectives of the study and further, the necessary ethical procedures for conducting the study. The details of the study including recourse avenues were given to the participants through an information sheet (appendix I). They were requested to provide signed consent (appendix II) once they agree to participate. Participant's confidentiality and anonymity were assured at all times. In this regard, all information gathered were stored in safe lockable custody. All information given was used strictly for research purposes only. Data collected was stored, analyzed and reported in formats that was concealed identities of the individual participants. Participation on the study was voluntary and without consequences for those who opted not to participate. There were no direct benefits to participants but the information collect is future reference for other researchers to improve the quality of life for the athlete's profession. No harmful procedures were undertaken therefore the process was safe for all the participants.

CHAPTER FOUR

RESULTS

4.1 Participant’s Response

The response rate for this study was 100%. None of the athletes screened and recruited for the study dropped out. None of the players withdrew from the study during the data collection process. Out of the targeted census of 1160 athletes in various training camps only 415 had a positive posterior thigh pain response. On further screening, 221 (53%) track runners were recruited into the study as having a hamstring injury.

Social demographics characteristics

4.1.1 Gender

Most of the participants (88.7%, n=196) were males and 11.3% (n=25) females.

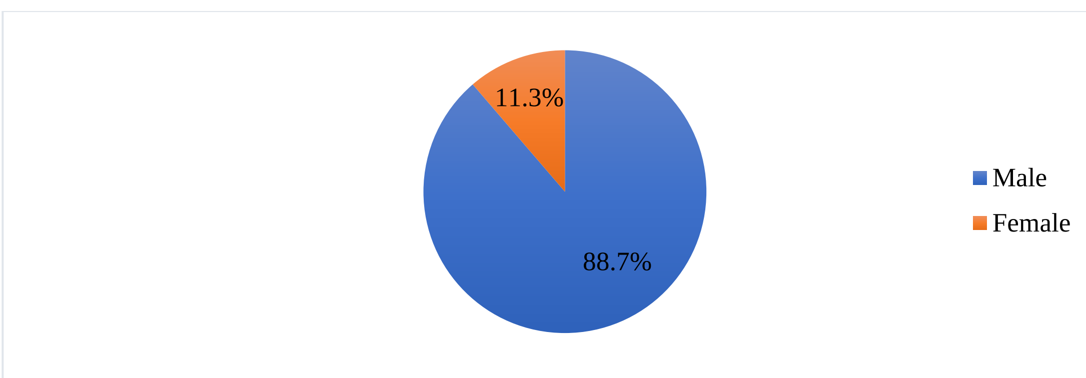

Figure 4.1: Gender

4.1.2 Age

More than a third of the participants (34.8%, n=77) were aged between 16 to 24 years, 28.1% (n=62) 25 to 30, 23.1% (n=51) 31 to 35 and 14.0% (n=31) more than 35 years.

The mean age was 27.4±6.4 years ranging between 16 to 38 years.

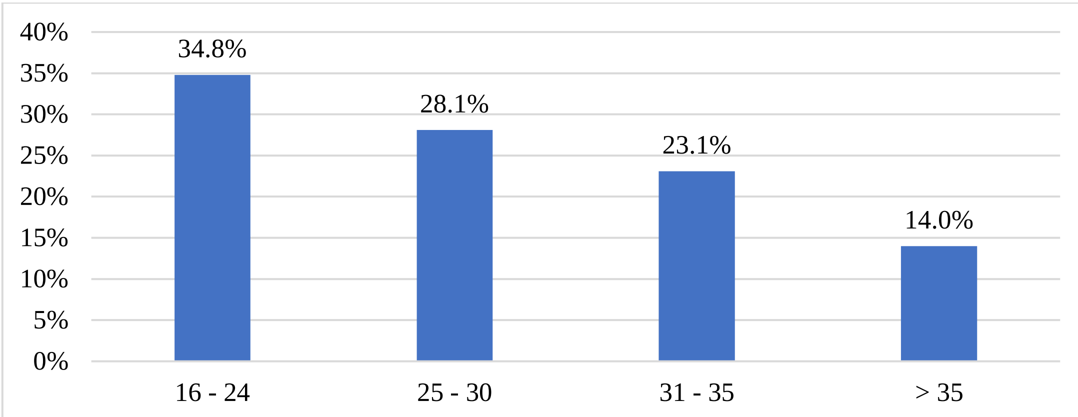

Figure 4.2: Age

4.2 Track Running Events

Most of the participants (81.1%, n=179) were long distance race runners (3000 M and above) as shown in table 4.1.

Table 4.1: Track Running Events

Event	Frequency (n)	Percent (%)
800 M	20	9.0
1500 M	22	10.0
3000 M	25	11.3
5000 M	26	11.8
5 000 M RR	30	13.6
10 000 M Track	22	10.0
10 000 M RR	21	9.5
Half marathon (21 KM)	25	11.3
Full marathon (42 KM)	30	13.6
Total	**221**	**100.0**

4.3 Objective 1: Point Prevalence of Hamstring Injuries by FASH Questionnaire (Functional Assessment Scale for Acute Hamstring Injuries)

Out of 730 athletes screened, 415 reported positive responses for posterior thigh pain, with 221 confirmed cases of hamstring injuries, resulting in a prevalence rate of 30.3%. The FASH classification categorized pain severity into three levels: severe, moderate, and minor, based on activities ranging from walking to full weight-bearing lunges.

Among the participants, 72 (32.6%) experienced severe pain during static stretching of the hamstrings, 71 (32.1%) reported severe pain while sprinting 30 meters, and 69 (31.2%) experienced severe pain during full weight-bearing lunges. These findings emphasize the significant impact of hamstring injuries on athletic performance and highlight the need for effective prevention and rehabilitation strategies.

More than a third of the participants (42.1%, n=93) experienced moderate pain/discomfort when performing partial weight bearing lunge, 38.5% (n=85) during jogging, 42.1% (n=93) on static stretching of hamstrings and 34.4% (n=76) during sprinting for 30 meters as seen in table 4.2.

Table 4.2: FASH Results

Hamstring muscle activities	Severe HI n (%)	Moderate HI n (%)	Normal n (%)
Pain during walking	29 (13.1)	68 (30.8)	124 (56.1)
Pain during jogging	42 (19.0)	85 (38.5)	94 (42.5)
Pain during sprinting for 30 meters	71 (32.1)	76 (34.4)	74 (33.5)
Pain on static stretching of hamstrings	72 (32.6)	93 (42.1)	56 (25.3)
Pain or discomfort when performing partial weight bearing lunge	31 (14.0)	93 (42.1)	97 (44.0)
Pain or discomfort when performing full weight bearing lunge	69 (31.2)	71 (32.1)	81 (36.7)

4.3.1 Severity of Hamstring Injuries

The general severity of hamstring injuries was arrived at by accumulating the activity scores of the specific severities per hamstring activity. As such, those scoring between 0-30 had severe injuries while those scoring between 31–70 had moderate injuries. In this regard, it was established that most of the respondents (70.6%, n=156) had moderate hamstring injuries and 29.4% (n=65) had severe hamstring injuries as seen in figure 4.3.

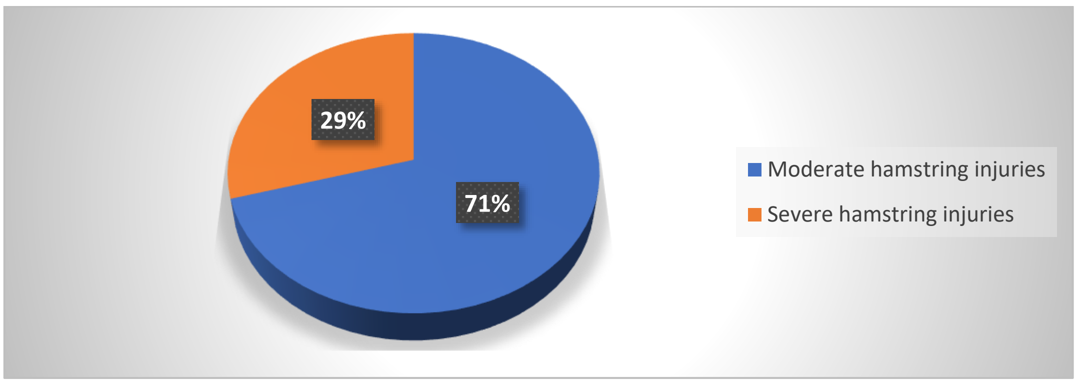

Figure 4.3: Severity of Hamstring Injuries

4.4 Objective 2: Post Rehabilitation Deviation of Performance

There was a marked deterioration of performance after hamstring injury among all the participants in their respective events. In 800M event the average deviation of time after hamstring injury post rehabilitation was 24 seconds. The 1500M participants recorded a deviation of 21 seconds after injury at their return to play. 3000M runners recorded a deviation of 31.7 seconds after injury post rehabilitation. The 5000M track runners recorded a deviation of 45 seconds while the 5000M road race had a deviation of 4 minutes. 10000M track runners had a deviation of 5 minutes as compared to the 10000M Road race who had a deviation of 3 minutes. The half marathon runners (21KM) had a deviation of 16 minutes after hamstring injury. Full marathon runners (42KM) had a deviation of 12 minutes at return to sport after rehabilitation as seen in table 4.3.

Table 4.3: Post Rehabilitation Time Deviation Before and After Hamstring Injury

Event		Personal Best	Time before	Time after
800 M	Mean	0:01:35:95	0:01:47:60	0:02:03:99
	N	20	20	20
	Std. Deviation	0:00:09:679	0:00:05:884	0:00:24:137
1,500 M	Mean	0:03:35.20	0:03:47.97	0:04:08.60
	N	22	22	22
	Std. Deviation	0:00:25.063	0:00:11.029	0:00:21.057
3,000 M	Mean	0:07:37.27	0:08:00.96	0:08:33.60
	N	25	25	25
	Std. Deviation	0:00:29.833	0:00:26.865	0:00:31.714
5,000 M	Mean	0:13:55.25	0:14:22.92	0:14:49.50
	N	26	26	26
	Std. Deviation	0:00:48.139	0:00:42.392	0:00:45.992
5,000 M RR	Mean	0:12:50.74	0:13:37.74	0:15:39.55
	N	30	30	30
	Std. Deviation	0:01:21.842	0:01:05.472	0:04:00.700
10 000M RR	Mean	0:31:30.70	0:31:58.26	0:33:08.08
	N	21	21	21
	Std. Deviation	0:03:48.086	0:03:42.389	0:03:26.117
Half Marathon (21 KM)	Mean	1:14:00.24	1:16:07.52	1:17:30.31
	N	25	25	25
	Std. Deviation	0:17:01.423	0:16:25.331	0:16:14.975
Full Marathon (42 KM)	Mean	2:17:19.46	2:18:05.36	2:22:12.02
	N	30	30	30
	Std. Deviation	0:10:54.804	0:11:06.879	0:12:45.174
10,000 M Track	Mean	0:30:53.92	0:31:50.10	0:34:16.73
	N	22	22	22
	Std. Deviation	0:03:06.121	0:02:37.683	0:05:59.134

4.4.1 Paired T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Time before(sec)	2312.635710407242000	221	2699.095007654831500	181.560778006067400
	Time after(sec)	2403.734656108592000	221	2762.359740669418000	185.816424477902640

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Time before(sec) & Time after(sec)	221	1.000	.000

The evidence provided by the negative mean difference of approximately -91.1 seconds, coupled with an extremely low p-value ($p < 0.001$), points to a clear and statistically significant enhancement in athletes' performance following the treatment. This finding is further supported by the 95% confidence interval of the difference, which excludes zero and substantiates the positive impact of the treatment on performance.

Therefore, the analysis strongly indicates that the treatment led to a noteworthy and meaningful advancement in athletes' performance across the various events.

4.5 Objective 3: Conventional Rehabilitation Strategies Used to Rehabilitate Hamstring Injuries

4.5.1 Observational Checklist on Hamstring Injury Treatment Protocols

Rehabilitation protocol purposed describing the criteria and design for exercises in each phase, the goals and test to progress between phases and RTP criteria.

The observational checklist on hamstring injury was completed by eleven physiotherapists. They were required to indicate whether they execute the prescribed treatment regime per every phase of injury.

During the pain and inflammation stage, at the acute phase, mode of treatment was remotely executed. The components of pain and inflammation management that involved physical activities such as closed kinetic movements were preferred by therapists at 45% more than pain relief and elimination of inflammatory circle regimes.

At the proprioception stage, it was evident from this study that re-education of proprioception was not prioritized, only 36.4%of the therapists conducted activities like knee flexion on unstable surface and low unstable dynamic movements. The rest of the activities were performed by less than 1/3 of the therapists.

Over 50% of the therapists did not give focus on active physiological movements to re-educate to full range dynamic exercises in all planes as preferred for the hamstring muscle treatment. Intervention which focuses on flexibility and ROM during the acute, sub-acute and functional phase of recovery was not keenly practiced by the therapists.

Strength and power intervention in all the phases of recovery process was fairly applied. More emphasis was directed on neuromuscular and fitness training such as walking on treadmill which was at 45.5% at the acute phase and 54.5% in sub-acute phase. Less emphasis was given to the goals and test to progress by therapists in acute sub-acute and functional phase.

At some point in the recovery process, athletes returned to strength and conditioning programs and resumed sport-specific activities in preparation for return to racing. The transition was important for several reasons. First, although the athlete may have recovered in medical terms such as improvements in flexibility, range of motion, functional strength, pain, neuromuscular control, and inflammation preparation for competition required the restoration of strength, power, speed, agility, and endurance at levels exhibited in sport This therefore indicated that there was deviation in time performance at the initial period of return to sport.

On full recovery, majority of the athlete’s performed even better indicating that the treatment protocols had a positive impact on their overall performance.

Return to play was defined as the process of deciding when an injured athlete may safely return to practice or competition. Early return to training and sport were considered sensible goals if the rate of return is based on the affected muscle, the severity of the injury and the position of the athlete.

Criteria for return to play emphasized gradual return to sport-specific functional progressions. Sport-specific function occurred when the activations, motions and resultant forces were specific and efficient for the needs of each activity. Sport-specific functional rehabilitation focused on restoration of the injured athlete’s ability to have sport-specific physiology and biomechanics to interact optimally with the sport-specific demands. That meant that they needed to be replicated at the same speed, on the same surface and with the same level of fatigue to be truly effective

Once an athlete had been medically cleared to return-to-play there are some fundamental steps that need to be followed.

- The athlete had to fulfil the fitness standards of the race he/she is returning to.
- The athlete needed to pass some skill specific tests applicable to respective race.
- The player may then began practicing with the team.
- Exposure to the race situation was gradual, with the race time gradually increasing.

There are simple guidelines which need to be developed by each team with contributions and support from each member of the medical team.

Table 4.4: Observational Checklist on Hamstring Injury Treatment Protocols

Exercise criteria		Yes n (%)	No n (%)	NI (not indicated) n (%)
Pain and inflammation				
Acute phase	Price	3 (27.3)	8 (72.7)	-
Sub-acute phase	Gentle movements	2 (18.2)	9 (81.8)	-
Functional phase	Closed kinetic chain movements	5 (45.5)	6 (54.5)	-
Proprioception				
Acute phase	Knee flexion 0 – 30 degrees	2 (18.2)	7 (63.6)	2 (18.2)
	Static movements	4 (36.4)	7 (63.6)	
	Low unstable dynamic movements	4 (36.4)	5 (45.5)	2 (18.2)
Sub-acute phase	Knee flexion 0 – 45 degrees	1 (9.1)	8 (72.7)	2 (18.2)
	Moderate reactive strength movements	1 (9.1)	8 (72.7)	2 (18.2)
	Active and wide movements	3 (27.3)	7 (63.6)	1 (9.1)
Functional phase	Knee flexion 0 – 90 degrees on unstable surface	4 (36.4)	6 (54.5)	1 (9.1)
	Intense reactive movements	3 (27.3)	8 (72.7)	-
Core				
Acute phase	Static exercises (stable surface)	3 (27.3)	8 (72.7)	-
Sub-acute phase	Dynamic exercises in all planes (stable surface to unstable point)	3 (27.3)	8 (72.7)	-
Functional phase	Dynamic exercises on two unstable points	5 (45.5)	6 (54.5)	
Flexibility and ROM				
Acute phase	Stretch with ESH≤45 avoid pain	2 (18.2)	9 (81.8)	-
	ESH≤45 isolated knee flexion or hip extension exercises	2 (18.2)	9 (81.8)	-
	Combine both knee flexion and hip extension	3 (27.3)	8 (72.7)	-
Sub-acute phase	Stretch with ESH≤70 avoid pain	1 (9.1)	8 (72.7)	2 (18.2)
	ESH≤70	3 (27.3)	5 (45.5)	3 (27.3)
	Combined movements	2 (18.2)	8 (72.7)	1 (9.1)
Functional phase	Stretch with no limit	3 (27.3)	7 (63.6)	
	ESH with no limit	3 (27.3)	6 (54.5)	2 (18.2)
	Length, Joint, Velocity, Load and Complexity	2 (18.2)	8 (72.7)	1 (9.1)
Strength and power				
Acute phase	Unipodal CKC exercises	5 (45.5)	4 (36.4)	2 (18.2)
	Bipodal CKC exercises	4 (36.4)	3 (27.3)	4 (36.4)
	ISOM, CONC and ECC	3 (27.3)	4 (36.4)	4 (36.4)
Sub-acute phase	OKC and CKC unipodal and bipodal exercises	3 (27.3)	6 (54.5)	2 (18.2)

Exercise criteria		Yes n (%)	No n (%)	NI (not indicated) n (%)
Functional phase	Horizontal strength exercises	2 (18.2)	7 (63.6)	2 (18.2)
Neuromuscular and fitness				
Acute phase	ESH≤45 avoid pain (soft surface to hard surface)	4 (36.4)	7 (63.6)	-
Sub-acute phase	ESH≤70 (soft surface to hard surface)	4 (36.4)	7 (63.6)	-
Functional phase	No ESH limit, hard surface	2 (18.2)	9 (81.8)	-
Goals and test to progress				
Acute phase	Walking on treadmill	5 (45.5)	6 (54.5)	-
	No pain or discomfort during exercises (neutral position)	1 (9.1)	10 (90.9)	-
	Find and maintain neutral position in static	2 (18.2)	9 (81.8)	
	Isometric knee flexion strength	3 (27.3)	8 (72.7)	-
	Isometric hip extension strength	1 (9.1)	9 (81.8)	1 (9.1)
	Full knee and hip isolated tested ROM	1 (9.1)	9 (81.8)	1 (9.1)
Sub-acute phase	Run on treadmill	6 (54.5)	4 (36.4)	1 (9.1)
	No pain or discomfort during exercises	2 (18.2)	9 (81.8)	-
	Isometric knee flexion strength	1 (9.1)	10 (90.9)	-
	Isometric hip extension strength	1 (9.1)	10 (90.9)	-
	Active hip flexion strength	1 (9.1)	10 (90.9)	-
Functional phase	No pain or discomfort during exercise	1 (9.1)	10 (90.9)	-
	Correct spine control and strength transfer exercise	4 (36.4)	7 (63.6)	-
	Strength, neuromuscular and proprioception	2 (18.2)	9 (81.8)	-
	Hip strength tests	2 (18.2)	9 (81.8)	-

Abbreviations: AKET, active knee extension test; CKC, close kinetic chain; CON, concentric; ECC, eccentric; ESH, elongation stress on hamstrings; HR, heart rate; ISOM, isometric; OKC, open kinetic chain; ROM, range of motion.

4.5.2 Paired T-Test to Assess the Impact of HI on Return to Sport Time

Results of the dependent (paired) sample t-test indicated that there were significant differences in time taken before and after acquiring hamstring injury. The average athlete performance time for all the events increased from 0:38:33.18 to 0:40:04.16. This implies that athletes took 0:01:30.97more time to complete track upon return to sport, t (220df) = -6.747, $p<.001$.Ideally, increased time to complete track event was observed across athletes participating in the different track events. A high time deviation of 0:04:06.66 was observed among full marathon athletes,

t (29df) = -3.629, $p=.001$.

Table 4.5: Impact of HI on Return to Sport Time

All track events	**Mean**	**N**	**SD**	**Std. Error Mean**	**Correlation**	**Sig.**
Time before	0:38:33.18	221	0:45:30.68	0:03:03.67	.998	<.001
Time after	0:40:04.16	221	0:46:39.05	0:03:08.29		

Paired Samples Test

	Full marathon paired differences			95% CI of the difference				
				Lower	Upper			
	Mean	SD	SE Mean			t	df	P
Time before Time after	-0:01:30.97	0:03:20.44	0:00:13.48	-0:01:57.55	-0:01:04.4	-6.747	220	000

Full marathon	**Mean**	**N**	**SD**	**Std. Error Mean**	**Correlation**	**Sig.**
Time before	2:18:05.36	30	0:11:06.88	0:02:01.76	.874	<.001
Time after	2:22:12.02	30	0:12:45.17	0:02:19.70		

Paired Samples Test

	Full marathon paired differences			95% CI of the difference				
				Lower	Upper			
	Mean	SD	SE Mean			t	df	P
Time before Time after	-0:04:06.66	0:06:12.25	0:01:07.96	-0:06:25.66	-0:01:47.66	-3.629	29	.001

4.5.3 Relationship between Determinants of Injury and Time Difference Pre- and Post-Injury

Results of the Pearson correlation indicated that there was a significant positive relationship between pain during sprinting for 30 meters, pain or discomfort when performing partial weight bearing lung, pain or discomfort when performing full weight bearing lunge and the time difference pre- and post- injury ($p<.05$).

Table 4.6: Relationship between Functional Assessment Activities and Time Difference Pre- and Post-Injury

	Pearson Correlation	Sig. (2-tailed)
Pain during walking	-.058	.389
Pain during jogging	.123	.067
Pain during sprinting for 30 meters	.151*	.025
Pain on static stretching your hamstrings	.100	.140
Pain or discomfort when performing partial weight bearing lunge	.219**	.001
Pain or discomfort when performing full weight bearing lunge	.206**	.002

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

4.5.4 Regression on Time Records

A simple linear regression was used to assess whether the FASH total scores (severity of injury) significantly predicts the time deviation pre- and post-injury. Results of a regression analysis showed a 4.8% variation between the pre- and post-injury time differences implying that 4.8% of the change in athlete performance time after injury can be explained by the model obtained from the data. Severity of the injury increase the amount of time that athletes took to complete track running event, $R^2 = .048$, $F(1, 117) = 5.85$, p<=. 017.severity of injury significantly predicted the performance time of athlete on return to sport injury (β=.048, t=2.419, p=.017.

Severity of injury did not predict time change between athlete's personal best and time before injury (p>.05). Similarly, severity of injury did not predict time change between personal best and time taken at sport after injury (p>.05).

Table 4.7: Regression on Time Records

Predictors	**R**	**R square**	**Adjusted R square**	**Std. Error of the Estimate**	**F**	**p-value**
Difference between time before and after injury	.218[a]	.048	.039	10.873	5.852	.017
Difference between personal best and time before	.061[a]	.004	-.005	11.120	2.386	.125
Difference between personal best and time after	.141[a]	.020	.012	11.029	.440	.508

Coefficients

Model		**Unstandardized Coefficients**		**Standardized Coefficients**		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	25.863	1.334		19.384	.000
	Difference between TB and TA	.048	.020	.218	2.419	.017

Dependent Variable: Total FASH Score

CHAPTER FIVE

DISCUSS, CONCLUSION, AND RECOMMENDATION

5.1 Discussion

The study revealed a high prevalence of hamstring injuries (30.3%, n=221) among athletes, aligning with findings from Eirale et al. (2018), who reported a 54.4% incidence rate in Qatar. Hamstring injuries have historically led to significant disruptions in athletic participation. In American athletics, the injury rate per 1,000 hours of exposure is notably higher during matches (2.7) than during training (0.47), indicating that competitive settings pose a greater risk for such injuries.

A substantial majority of injuries occurred in males (88.9%, n=196), consistent with findings from Kuske et al. (2016), which noted that 81.3% of hamstring injuries were among males. This may reflect the demographic composition of the sampled population. The mean age of participants was 27.4 years (SD±6.4), with most injuries occurring in athletes in their 20s and 30s. This age range is commonly associated with higher activity levels, but also with increased susceptibility to injuries due to factors like insufficient leg strength (Sugiura et al., 2017).

The findings suggest a critical need for strength training, especially in youth athletes, to enhance muscular stabilization during eccentric contractions (Granacher et al., 2016). Additionally, the study highlighted that a significant portion of marathon runners were master athletes (46.7%, n=14, aged over 35). Although experience in training can improve performance, aging is linked to a heightened risk of hamstring injuries due to various age-related physiological changes (Gabbe et al., 2019).

Effective injury prevention strategies, such as Nordic hamstring exercises, have been shown to reduce hamstring injuries (Ribeiro-Alvares et al., 2018). Furthermore, long-term endurance training can lead to beneficial cardiac adaptations (Nottin et al., 2004), emphasizing the importance of consistent training in maintaining cardiovascular and muscular health.

The study found that athletes took longer to return to their personal best times after injury, with mean marathon performance times post-injury increasing from 2 hours 18 minutes to 2 hours 22 minutes. This aligns with findings from Anderson & Green (2018) and Verrall et al. (2016), which indicated that return-to-sport performance is often impaired after injury. A paired t-test confirmed significant differences in performance ratings before and after injury ($p<.001$), underscoring the importance of full rehabilitation before resuming competitive activities.

Pain experienced during specific activities, such as sprinting and lunges, was significantly correlated with the time taken to return to pre-injury performance levels. This aligns with Jonhagen et al. (2021), who noted that previously injured runners often exhibit weakened muscle contractions. The regression analysis indicated that total FASH scores could predict time differences between pre- and post-injury performance, accounting for 4.8% of the variation ($R^2 = .048$, $p <= .017$).

Overall, the findings highlight the importance of adequate rehabilitation to restore strength, flexibility, and function. Athletes should undergo thorough assessments to ensure readiness to return to sport, focusing on achieving full range of motion and strength (Heiderscheit et al., 2019). The implications of these findings suggest that targeted training and rehabilitation strategies are crucial for preventing hamstring injuries and optimizing athletic performance.

The study found that athletes experienced longer performance times post-injury compared to their personal bests, indicating a decline in competitive performance. Specifically, marathon runners recorded a mean time of 2 hours 22 minutes after injury, compared to 2 hours 18 minutes before. This aligns with Anderson & Green (2018), who noted that athletes often struggle to return to their personal bests after injuries. The findings emphasize the importance of tailored rehabilitation programs focusing on strength, flexibility, and functional performance to ensure athletes are fully recovered before returning to sport.

A paired t-test confirmed significant differences in performance before and after injury ($p<.001$), corroborating findings from Verrall et al. (2016), which showed substantial drops in performance levels following hamstring injuries. This decline can be attributed to athletes returning to sport before fully recovering, leading to mechanical alterations, such as changes in muscle length and force production. Lord et al. (2019) found a 13% reduction in mean force production in previously injured footballers, highlighting the impact of hamstring injuries on athletic performance. Regular assessments of pain and performance metrics are crucial for making informed decisions about an athlete's readiness to return to competitive activities.

Additionally, a systematic review by Maniar et al. (2016) indicated deficits in hamstring strength and flexibility in injured athletes, reinforcing the need for thorough clinical evaluations before returning to sport. Athletes should only resume competitive activities after achieving full range of motion, strength, and functional capabilities (Heiderscheit et al., 2019). Strength training, particularly targeting eccentric contractions and overall muscle stability, is vital for reducing the risk of hamstring injuries, especially among young athletes. Strength training, particularly targeting eccentric contractions and overall muscle stability, is vital for reducing the risk of hamstring injuries, especially among young athletes.

Coaches and athletes should manage expectations regarding performance post-injury, understanding that recovery may take time and that achieving pre-injury performance levels may not happen immediately.

The study also found a significant positive correlation ($p<0.05$) between pain experienced during various exercises and the time difference between pre- and post-injury performances. This aligns with Jonhagen et al. (2021), who noted that injured runners often exhibit weaker muscle contractions, leading to persistent pain and performance deviations.

Regression analysis revealed that total FASH scores accounted for 4.8% of the variation in performance time differences ($R^2 = .048$, $p <= .017$), indicating that pain levels can significantly predict recovery outcomes. Factors contributing to lower performance include reduced tensile strength, muscle strength, and flexibility (Comfort et al., 2009). Integrating conditioning, flexibility work, and injury prevention strategies into training regimens can help mitigate the risks associated with hamstring injuries and enhance overall athletic performance

Return to sport before full recovery after hamstring injury is one of the pre-disposing factors of re-injury (Hamstring et al., 2018). Proper rehabilitation should be done before return to sport to enable athletes perform well and also avoid reoccurrence episodes of injury. Permission for sport participation should not be granted to athletes who are not yet fully rehabilitated. Treatment for hamstring injuries includes rest and immobilization after acquisition of injury and a progressive increase program of mobilization, strengthening, and activity. The best treatment for hamstring injuries is prevention, which should include training to maintain and/or improve strength, flexibility, endurance, co-ordination, and agility through Nordic exercises (Agre, 2019). The hamstring rehabilitation protocol was not adhered to across all guideline domains hence pre-disposing the athletes to incidents of reoccurring hamstring injury on return to sport.

5.2 Conclusion

Hamstring injuries significantly affect an athlete's performance upon returning to sport, particularly in their season bests. Here are some key effects: Athletes often record slower times and reduced performance levels post-injury compared to their personal bests. Studies show that marathon runners may experience an increase in completion times, indicating a drop in performance capability. The time taken to regain peak performance can be extended, with many athletes taking longer to return to their previous competitive levels. This can impact overall season performance and potentially lead to missed opportunities in competitions

The study concludes that the prevalence of hamstring injuries among endurance runners in Kenya's Rift Valley region is still so high. A rate of 29.4% acute hamstring injuries insinuates a lifetime impact in runners health more so the physical well-being. The fact that most athletes come from this region forms the basis for future research to further investigate factors contributing to hamstring injuries and interventions to prevent re-injury or and lower injury rates.

The study also concludes that athletes took more time after injury compared to their personal best and before injury time records. The average best time for full marathoners was 2:17:19.46 (SD±0:10:54.804), before injury 2:18:05.36(SD±0:11:06.879) and after injury 2:22:12.02 (SD±0:12:45.174). Athletes are required to weigh up carefully the advantages and disadvantages of returning to sport . This has had physiological, emotional and psychological impacts on most athletes, with long term effects to those in poor athletic management.

The observational checklist of hamstring injury treatment protocols was not adequately used. Lower numbers of use were observed across all the domains of the guideline. This has had a negative impact in future athletic performance on most athletes leading to early end of athletic careers of would long term performers in track and field.

5.3 Recommendations

1. Practice

- **Early Education on Injury Prevention:**

  Implement training programs for young athletes that focus on injury avoidance techniques, including proper warm-up and cooldown routines.

Regularly integrate Nordic hamstring exercises into training regimens to enhance muscle strength, particularly in the hamstrings, and improve eccentric strength.

Prioritize comprehensive strength training sessions before athletes return to sport, specifically targeting deficits in muscle strength and eccentric control.

Conduct ongoing evaluations of an athlete’s recovery, focusing on strength, flexibility, and functional performance to determine readiness to return to sport.

2. Policy

- **Strict Adherence to Rehabilitation Protocols:**

  Establish strict guidelines to ensure that rehabilitation protocols are meticulously followed. Athletes should only return to sport once they have demonstrated full recovery and adherence to the prescribed rehabilitation program.

- **Enhanced Athlete Management:**

  Develop a collaborative approach among coaches, trainers, and medical staff to monitor training loads, recovery status, and performance metrics, ensuring a holistic view of the athlete’s health and readiness.

3. Further Research

- **Investigation of Long-term Effects:**

  Conduct longitudinal studies to assess the long-term effectiveness of Nordic exercises and strength training in preventing hamstring injuries among athletes.

- **Evaluation of Rehabilitation Protocols:**

  Research the impact of different rehabilitation protocols on return-to-sport outcomes, focusing on optimal timing and methods for resuming training post-injury.

- **Biomechanical Analysis:**

  Explore the biomechanical changes in athletes pre- and post-injury to better understand the factors that contribute to hamstring injuries and develop targeted prevention strategies.

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APPENDICES

Appendix I: Information Sheet

Study Title: Impact of hamstring injuries on athlete's season best performance at return to sport phase of rehabilitation amongst track runners in high altitude training camps in Kenya.

Institution: Jomo Kenyatta University of Science and Technology (JKUAT).

Study site: High altitude training camps in western Kenya Region.

Dear Participant

My name is Emily Koskei, a student at Jomo Kenyatta Universityof Agriculture and Technology studying Maters of science Degree in Physiotherapy. I would like to carry out this research on **Impact of hamstring injuries on athlete's season best performance at return to sport phase of rehabilitation amongst track runners in high altitude training camps in Kenya.** This research is part of the requirement for the award of the mentioned degree. As a participant, you are kindly requested to participate by filling the questionnaire

All information you provide will be for purposes of research only. Participating in this study will not expose you to any physical or psychological harm whatsoever. Throughout this study, your identity will be concealed, and any information you provide will be confidential, and your privacy will be respected. Your participation is purely voluntary and you are free to withdraw at any point without any penalty. In case you need any more information kindly enquire at any time.

Thank you

Purpose and benefits of the study

The study is important in regards to hamstring injuries amongst athletes in Kenya. Little has been done regarding the impact of hamstring injuries amongst athletes and this study will provide evidence to that effect.

Procedure

If you are willing to participate in the study, you will meet with a research assistant who will give you a questionnaire to fill/ or interview you. You are free not to answer any question that you may feel uncomfortable with. If you need any assistance to answer the questionnaire, the researcher will be available. Please do not hesitate to contact me (The principle investigator) or my supervisors on the telephone numbers provided below for further clarification. No invasive procedure will be employed.

Visits

Participants will be visited at their training camps and the study will be conducted when the participant is free and will not interfere with the training schedules.

Consent

Prior to participation in either filling the questionnaires, consent will be sought. This will be done by explaining to the participants all the information about the study, and reading through the Consent information form. They will then be asked to give an informed consent by signing the consent form before the start of the study.

Benefits of taking part in the study

There may be no direct benefit to you for taking part in the study. The information we will gather from this exercise will help us in understanding common hamstring injuries amongst athletes/runners in high altitude training camps in Kenya. This will help in policy formulation and in finding ways of ensuring that hamstring injuries amongst runners is reduced.

Confidentiality

All questionnaires are to be completed anonymously. No personal identification information will be collected on the questionnaire. Data access will be controlled and only the data entry clerk, the statistician and the principal investigator will access the information which will be password protected. Uncontrolled copying of data to removable disks will be prohibited. All hard copies from the field or draft reports will be under lock and key. Furthermore, results of this study will be presented in aggregate form, so no individual responses will be able to be traced back to individuals.

Risk, stress and discomfort

The questionnaire used to interview you will not have your name or other details which can identify you. You will receive no money for participating in this exercise. The only discomfort is when you will be taking about a few minutes of your time to complete the questionnaire.

Contacts

If you wish to make an enquiry or clarification; please use the following contacts:

Emily Koskei

+254722977372

The chairman of department, rehabilitation sciences- JKUAT

+254734282692

The Secretary, JKUAT IERC,

P. O. BOX 62000,00200 Tel 0675870225 Extn 3209

Appendix II: Consent Form

Participants Declaration

I confirm that I have understood the information provided for the above study and have had the opportunity to ask questions. I also understand that my participation is voluntary and that I am free to withdraw at any time, without giving reasons. I agree to take part in the above study.

My signature below means that I voluntarily agree to participate in this research study

……………………. ……………………………….

Date Signature

………………………………... ……………………..

………………..

Name of Research assistant Date

Signature

If you have any questions about this study you can contact:

1. EMILY KOSKEI (**Principal Investigator).** Kenyatta National Hospital. P.O BOX 20723, 00202Tel. 0722 977 372 NAIROBI
2. DR. WALLACE KARUGUTI (**supervisor).** College of Health Science, Rehabilitation Department **JKUAT,** P.O BOX 62000-00200, 00202 Tel 0675870225**.** NAIROBI.
3. DR. JOSEPH MATHERI (**supervisor).** College of Health Science, Rehabilitation Department**, JKUAT,** P.O BOX 62000-00200, 00202 Tel 0675870225**.** NAIROBI.

The Secretary IERC, P. O. BOX 62000-00200, Extn 3209.

Appendix III: Data Collection Tool (FASH- Functional Assessment Scale for Acute Hamstring Injuries)

Q1. If you have had an acute hamstrings injury, please rate your current level of pain and/or, discomfort.

0	1	2	3	4	5	6	7	8	9	10

Q2. Are you currently taking part in your sport, training or, other Physical activity?

Yes	No

Q3. How much pain do you have during walking?

0	1	2	3	4	5	6	7	8	9	10

Q4.How much pain do you have during jogging or, slow pace Running, (Jogging)?

0	1	2	3	4	5	6	7	8	9	10

Q5. How much pain do you have during accelerating or, sprinting for 30 meters?

0	1	2	3	4	5	6	7	8	9	10

Q6. How much pain do you have during static stretching your hamstrings (toe touch in standing)?

0	1	2	3	4	5	6	7	8	9	10

Q7. Do you have pain or, discomfort when performing a partial weight-bearing lunge?

0	1	2	3	4	5	6	7	8	9	10

Q8. Do you have pain or, discomfort when performing a full weight-bearing lunge?

0	1	2	3	4	5	6	7	8	9	10

Q9. Can you perform one Nordic exercise (partner exercise where you attempt to resist a forward-falling motion using your hamstrings throughout the whole range of motion to the ground)?

YES	NO

Q10. Can you perform 3 one-legged jumps for distance?

YES	NO

Instructions

For questions 1, 3-8 (numerical rating). A score of 0(zero) means worst results or severe symptoms. A score of 10(ten) means best results (no symptoms).

Questions 2, 9 and 10 are categorical rating system on incremental range. Only answer Yes or No.

Appendix IV: Observational Checklist on Hamstring Injury Treatment Protocols

Rehabilitation Protocol Purpose Describing the Criteria to Design the Exercises in Each Phase, the Goals and Test to Progress between Phases and RTP Criteria. The observational checklist on hamstring injuries was completed by eleven physiotherapists. They were required whether they executed the prescribed treatment regime per every phase of injury. During the acute phase of injury where pain and inflammation was present 8 (72%) did not executed PRICE mode of treatment. The components of pain and inflammation management that involved physical activities such as CKC movement were preferred by therapists at 45% more than pain relieve and elimination of inflammatory circles regime.

During proprioception it was evident that reeducation of proprioception was not prioritized. Only 36.4% of the therapists conducted activities with knee flexion on unstable surfaces and low unstable dynamic movement in the interest of reeducation of proprioception. The rest of the activities were performed by less than a third of the therapists.

Core activities over 50% of therapist didn't give focus on active physiological movements on reeducatio to full range dynamic exercises in all planes as performed by the arm string muscle. Over 50% of th therapists did not give focus on neuromuscular and fitness activities on soft surface, hard surface and t the limit of pain. It was noted that goals and test to progress by walking on treadmill was practiced by th therapists at 54.5%. Sports specific test on strength, flexibility, spine control and proprioception at thi phase was not keenly done. **Table 1.** Rehabilitation Protocol: Purpose: Describing the Criteria to Desig the Exercises in Each Phase, the Goals and Test to Progress Between Phases and RTP Criteria.

Exercise design criteria	**Acute Phase**	**Sub-acute Phase**	**Functional Phase**
1.Proprioception	Start on a stable surface and progress to light instability (soft mat, dyna-disk or similar). Knee flexion, start 0° and progress until 30°. Static movement and	Increase instability (bosu, balance board, rocker board or similar). Knee flexion, progress to 45°. Moderate reactive/strength movement. Active and wide movements.	Unstable surface. Knee flexio progress to 90°. Intens strength and reactiv movements.

		progress to low unstable dynamic.		
	2. Core	Static exercises on stable surface in frontal, sagittal and transverse planes.	Dynamic exercises in frontal, sagittal and transverse planes from stable surface and progress to one unstable point; unstable elements progressing in instability (soft mat to fitball).	Dynamic exercises on tw unstable points. Exercises i standing position reproducin functional movement (acceleration, deceleration, an dynamic stabilization). N limit.
4	Flexibility and ROM	Stretch with ESH ≤ 45, avoiding pain.	Stretch with ESH ≤ 70, avoiding pain.	No limit.
5	Strength and power	ESH ≤ 45, avoiding pain. Isolated knee flexion or hip extension exercises, progress to combine both actions. When starting CKC exercises, first unipodal and progress to bipodal. In the corresponding ESH start with ISOM, progress to CONC and ECC and progress in muscle length avoiding pain or discomfort.	ESH ≤ 70 avoiding pain. In the corresponding ESH, progress in analytic movements length, velocity and load to the maximum effort; and increase combine movement demands. OKC and CKC uni and bipodal exercises.	No ESH limit. Progress i length, joint velocity, load an complexity. Horizonta strength application exercises.
6	Neuromuscular and fitness	ESH ≤ 45, avoiding pain. Start on a soft surface and progress to hard (to reduce eccentric contraction). Start walking on treadmill and progress until V max ≤ 8 km/h, 5% slope to decrease ESH	ESH ≤ 70 avoiding pain. Start on a soft surface and progress to hard. Run on treadmill, progress until 70% of athletes maximal speed, 3 % slope to decrease ESH	No ESH limit. On hard surface Progress until maximal speed start on flat and progress t negative slope

7 **Goals and test to progress**	No pain or discomfort during exercises. To find and maintain a neutral spine position in static (laying, standing or sitting) and during exercises. Isometric knee flexion strength, decubitoprono knee flexion 45° and hip 0° > 50% of previous data or uninjured leg (dynamometer or similar). Isometric hip extension strength, decubito supine hip flexion 45° and Knee 0° > 50% of previous data or uninjured leg (dynamometer or similar). Full knee and hip isolated tested ROM	No pain or discomfort during exercises. Not tilting the pelvis or flattening the spine during exercises. Isometric knee flexion strength in decubitosupino knee flexion 25° and hip flexion 45°, less than 10% asymmetry from previous data or uninjured leg (dynamometer or similar). Isometric hip extension strength in decubitosupino knee 0° and hip flexion 70°, less than 10% asymmetry from previous data or uninjured leg (dynamometer or similar). Less than 10° asymmetry in in AKET Less than 10° asymmetry in the Active Hip Flexion Test. Modified Thomas test > 5 and symmetry below horizontal. Deep squat test (50). Single leg squat (51). Runner pose test (51). In-line lunge test (50).	No pain or discomfort durin exercises. Correct spine contro and strength transfer durin exercises. Integrate strength neuromuscular an proprioceptive work. Hi strength test in bipedestatio knee 0° hip at maximum hi flexion achieved i contralateral leg, no asymmetr (dynamometer or similar) Isokinetic criteria: Difference higher than 20% should b avoided in absolute values Normal isokinetic ratios N asymmetry in the Active Hi Flexion Test. No asymmetry i AKET
Days post injury			
YES			
NO			
REMARKS			

Criteria Functional Test

Normal week training with the group, without pain, discomfort or "fears". Normal performance by GPS or similar (distances, speeds, accelerations), and HR data (training zones%, etc).

Athlete "psycho"

Full performance feelings and no fear/doubts from player or similar expression to describe a positive feeling from the subject.

Clinical Test

Free pain maximal eccentric knee extension in decubito prone hip 0° knee 90° and moves to 0°; and free pain maximal eccentric hip extension in decubito supine knee 0° hip 0° and moves to 70°.

Abbreviations:

AKET, active knee extension test; CKC, close kinetic chain; CON, concentric; ECC, eccentric; ESH, elongation stress on hamstrings; HR, heart rate; ISOM, isometric; OKC, open kinetic chain; ROM, range of motion.

Appendix V: ERC Letter

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
P. O. Box 62000-00200 Nairobi, Kenya Tel 0675870225 OR Extn 3209
Institutional Ethics Review Committee

September 11th, 2019 **REF: JKU/2/4/896B**

Emily C. Koskei,
Department of Rehabilitation Sciences.

Dear Mrs. Koskei,

RE: EFFECT OF HAMSTRING INJUIES ON ATHLETE'S SEASON BEST PERFORMANCE AT RETURN-TO-SPORT PHASE OF REHABILITATION: A SURVEY OF TRACK RUNNERS IN HIGH ALTITUDE TRAINING CAMPS IN KENYA

The JKUAT Institutional Ethics Review Committee has reviewed your responses to issues raised regarding your application to conduct the above mentioned study with you as the Principal Investigator.

This is to inform you that the IERC has approved your protocol. The approval period is from September 11th 2019 to September 11th 2020 and is subject to compliance with the following requirements:

a) Only approved documents (informed consent, study instruments, study protocol, etc.) will be used.
b) All changes (amendments, deviations, violations, etc.) must be submitted for review and approval by the JKUAT IERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the IERC immediately.
d) Any changes, anticipated or otherwise that may increase the risks to or affect the welfare of study participants and others or affect the integrity of the study must be reported immediately.
e) Should you require an extension of the approval period, kindly submit a request for extension 60 days prior to the expiry of the current approval period and attach supporting documentation.
f) Clearance for export of data or specimens must be obtained from the JKUAT IERC as well as the relevant government agencies for each consignment for export.
g) The IERC requires a copy of the final report for record to reduce chances for duplication of similar studies.

Should you require clarification, kindly contact the JKUAT IERC Secretariat.

Yours Sincerely,

DR. PATRICK MBINDYO
SECRETARY, IERC

INSTITUTIONAL ETHICS REVIEW COMMITTEE
11 SEP 2019
APPROVED

JKUAT is ISO 9001:2015 and ISO 14001:2015 Certified
Setting Trends in Higher Education, Research, Innovation and Entrepreneurship

Appendix VI: Athletics Kenya Authorization Letter

Affiliated to I.A.A.F, C.A.A, N.O.C.K, K.N.S.C
Riadha House, Aerodrome Road, Nairobi West. P.O. Box 46722-00100 G.P.O. Nairobi, Kenya
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ATHLETICS KENYA

AK/ADMIN/VOL.38/02/2020

Wednesday, January 22, 2020

TO WHOM IT MAY CONCERN

RE: EMILY C. KOSKEI – PERMISSION TO COLLECT DATA FROM ATHLETES IN KENYA

Athletics Kenya has authorized Ms. Emily C. Koskei a student pursuing Masters in Sports Physiotherapy at Jomo Kenyatta University of Agriculture and Technology to conduct a research and survey by collecting data towards her study of track runners in high altitude training camps in Kenya on the" *effect of hamstring injuries on athlete's season best performance at return to sport phase rehabilitation.* "

We kindly request that you accord Ms.Koskei necessary assistance to enable her conduct the survey on Kenyan athletes for a period of 1 year until 22nd January 2021.

Please do not hesitate to contact the undersigned should you need any clarification.

Thank you.

Yours faithfully,

SUSAN K. KAMAU
CHIEF ADMINISTRATIVE OFFICER

ATHLETICS KENYA, RIADHA HOUSE, AERODROME ROAD, NAIROBI WEST, P.O. Box 46722-00100 NAIROBI, TEL: +254 (20) 6005021, (736)747217

CC: DR. PATRICK MBINDYO
JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY