RESEARCH PAPER

A Comparative Study Between RSRLAPB Exercise and Functional Range Conditioning (FRC) On Iliotibial Band Tightness and Gluteus Medius Weakness for Improving Lateral Hip Instability in Long-Distance Runners

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ABSTRACT
Iliotibial band (ITB) tightness and gluteus medius weakness are common contributors to lateral hip instability in long-distance runners, often leading to impaired performance and increased injury risk. Effective rehabilitation strategies targeting both mobility and strength are essential for optimal recovery. To compare the effectiveness of Right Sidelying Respiratory Left Adductor Pull Back (RSRLAPB) exercise and Functional Range Conditioning (FRC) in improving hip adduction range of motion, gluteus medius strength, functional ability, and lateral hip stability in long-distance runners. A total of 60 participants were randomly allocated into two groups: RSRLAPB (n=30) and FRC (n=30). Both groups underwent a 6-week intervention program, three sessions per week. Outcome measures included hip adduction ROM, gluteus medius strength (hand-held dynamometer), Lower Extremity Functional Scale (LEFS), and Single Leg Squat (SLS) test. Data were analyzed using paired and independent t-tests, along with correlation and regression analysis. Both groups showed significant improvements across all variables ($p < 0.001$). However, the FRC group demonstrated significantly greater improvements in ROM, strength, LEFS scores, and SLS performance compared to the RSRLAPB group. Strong correlations were observed between strength and functional ability, and regression analysis confirmed their predictive relationship. While both interventions were effective, Functional Range Conditioning proved to be superior in improving mobility, strength, and dynamic stability, suggesting its potential as a more comprehensive rehabilitation approach for lateral hip instability in long-distance runners.
Keywords: Iliotibial band syndrome, Functional Range Conditioning, Gluteus medius strength, Hip stability, Long-distance runners

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1. INTRODUCTION

Long distance and endurance running have over the past years become significantly more popular, and have led to an enhancement on the physical fitness of the runners, and an equivalent increase in overuse injuries on the runners [1]. These injuries include iliotibial band syndrome (ITB) which is among the most commonly reported injury to the lateral knee and hip, especially among those who are involved in a repetitive running activity [2]. The use of conservative treatment measures has been very common in managing this condition but there has been inconsistency in the outcome, so more specific rehabilitation methods should be used [3]. ITB syndrome pathophysiology comprises complicated biomechanical and neuromuscular processes, such as the inappropriate load distribution and the recurrent friction of the ITB on the lateral femoral epicondyle [4]. The biomechanical aspects of running are by nature associated with cyclical repetitive loading and long periods of single-leg stance, which makes a heavy load on the hip stabilizing muscles [5]. One of them is the gluteus medius muscle, which is important in keeping the pelvis in position and in regulating the hip movement during the stance phase of gait [6]. In case of weak or insufficient activation of the gluteus medius, the compensatory mechanisms are established, which in turn results in a greater dependence of the lateral stability on the tension of the tensor fascia lata (TFL) and iliotibial band [7]. The consequences of this overcompensation are the build-up of tension in the ITB, loss of flexibility, and distortions in lower limb kinematics. These biomechanical changes over time lead to inefficient movement patterns, reduced shock absorption and predisposition to injury [8]. The deficit in gluteal muscle activation also has a major impact on functional performance and dynamic stability as evidenced in the studies of physically active populations [9]. The impairments can be in the form of poor control in the single-leg activities like running and squatting, which in the end leads to instability of the lateral hip.

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Thus, ITB tightness and gluteus medius weakness need to be considered in the treatment of the long-distance runners to achieve the right biomechanics and avoid the recurrence of the injury.

Recent studies have focused on the importance of biomechanical pathophysiology, such as unbalanced hip kinematics and muscle imbalances, in the pathogenesis of ITB syndrome in runners [10]. Neuromuscular control strategies and coordinated muscle activation methods of rehabilitation have demonstrated encouraging outcomes in enhancing movement effectiveness and decreasing the risk of injury [11]. Likewise, interventions based on stretching have also been investigated on their possible positive effects on flexibility and running performance, but isolated effects of these interventions might be restricted [12]. Besides this, hip abductor strengthening has also been repeatedly found to be a major contributor in lower extremity injuries as well as functional performance of runners [13]. The clinical guidelines also recommend the implementation of holistic approaches to rehabilitation because they combine strength, mobility, and neuromuscular training to treat the underlying impairments [14].

Regardless of such results, comparative studies to assess various rehabilitation methods to achieve neuromuscular alignment and joint mobility are still lacking. In particular, none of the studies has directly compared the efficacy of the Right Sidelying Respiratory Left Adductor Pull Back (RSRLAPB) exercise and Functional Range Conditioning (FRC) as the means of controlling iliotibial band tightness and gluteus medius weakness. Moreover, there is a dearth of evidence in the literature covering an integrated intervention in the management of lateral hip instability in long-distance runners, which presents an important gap in the literature.

The conservative approach to ITB syndrome treatment is often based on the management of symptoms but not the biomechanical and neuromuscular deficits [15]. Nevertheless, there are signs that these root causes should be targeted to obtain long-term results of rehabilitation. Distorted lower limb biomechanics has been cited as one of the key factors that can result in the onset and maintenance of running-related injuries [16]. The condition is aggravated by intrinsic risk factors, such as muscle weakness, limited range of motion, and inadequate neuromuscular control, which make the recurrence more likely [17]. Programs of rehabilitation that integrates both strengthening and functional movement training have shown pain, functional and overall performance improvement in runners [18].

Due to the complementary nature of the RSRLAPB intervention that aims to address neuromuscular re-education and pelvic alignment, and the Functional Range Conditioning (FRC) that aims to address end-range mobility and strength, a comparative analysis of the interventions is clinically warranted. This kind of investigation will be useful in giving information on their comparative usefulness in the prevention of tightness of ITB, the improvement of the gluteus medius functioning and the lateral stability of the hip in long distance runners.

Research Objectives

1. To evaluate the effect of RSRLAPB exercise on hip adduction range of motion, gluteus medius strength, functional ability, and lateral hip stability in long-distance runners.
2. To assess the effect of Functional Range Conditioning (FRC) on hip adduction range of motion, gluteus medius strength, functional ability, and lateral hip stability in long-distance runners.
3. To compare the effectiveness of both interventions using hip adduction ROM, dynamometric strength assessment, Lower Extremity Functional Scale (LEFS), and Single Leg Squat test.

2. METHODOLOGY

2.1 Study Design

The study design applied in this study was experimental comparative design that involved two intervention arms. This implied a pre test and post test design that measured the changes in outcome measures before and after intervention period whereby a within group and between group could be compared in terms of effectiveness.

2.2 Sample Size, Sampling Method, and Study Population

The study involved a total of 60 participants, which were evenly divided into two groups, 30 participants in Group A (RSRLAPB Exercise Group), and 30 participants in Group B (Functional Range Conditioning Group). The recruitment of participants was done through a purposive sampling approach of long-distance runners who are members of the running communities, fitness clubs, and sports facilities in Ahmedabad city and both recreational and competitive runners who fit the specified eligibility criteria.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria were willingness to participate and informed consent, recreational or competitive level long-distance runners between the ages of 18 and 45 years, both sexes, a history of at least 3 days per week of running in the past 6 months with a weekly running volume of 20km or greater, and a positive Ober test and left gluteus medius weakness measured by a hand-held dynamometer. The participants were not included when they had a history of lower limb injury in the last 6 months, prior hip surgery or trauma, neurological or vestibular conditions that could influence gait or balance, were involved in other hip or gluteal rehabilitation programs during the study or had systemic conditions that could influence lower limb strength or balance.

2.4 Intervention Protocol

The duration of the intervention was 6 weeks, and the number of sessions was three per week, with a 5-minute warm-up of light walking or jogging. Group A participants used the Right Sidelying Respiratory Left Adductor Pull Back (RSRLAPB) exercise, where the emphasis is on pelvic repositioning, diaphragmatic breathing, and adductor muscle activation to promote

neuromuscular re-education of pelvic stabilizers, and the load is increased over the course of the intervention. Group B involved Functional Range Conditioning (FRC), involving controlled articular rotations (CARs), progressive angular isometric loading (PAILs and RAILs), end-range strengthening exercises, lift-offs, and side plank progression to improve joint mobility, strength, and dynamic stability, with increased intensity over the 6 weeks.

2.5 Outcome Measures

The outcome measures were measured at baseline and after 6-week intervention period and they included hip adduction range of motion (ROM) to determine iliotibial band flexibility, gluteus medius strength as measured using a hand-held dynamometer, Lower Extremity Functional Scale (LEFS) to assess functional ability, and Single Leg Squat (SLS) to assess dynamic hip stability.

2.6 Statistical Analysis

The obtained data were entered into MS Excel. All outcome variables were analyzed using descriptive statistics (mean and standard deviation). The t-tests were conducted in pairs to determine differences between the pre and post-intervention values within each group, and independent t-tests were conducted to determine differences between the two groups. Also, Pearson correlation analysis was carried out to see the associations between the variables and the linear regression analysis to see the predictive power of the chosen variables on the functional outcomes. The statistic significance level was set to $p < 0.05$.

3. RESULTS

The participants in the study were 60 long distance runners with equal representation in the RSRLAPB and Functional Range Conditioning (FRC) groups. Each and every participant went through the intervention protocol and their data were evaluated to determine the differences in hip adduction range of motion (ROM), gluteus medius strength, functional ability, and dynamic hip stability.

3.1 Demographic Characteristics

The demographic distribution indicated a comparable representation of male and female participants across both groups, with a slightly higher proportion of male runners in each group. This distribution reflects the typical participation trends seen in long-distance running populations and ensures that the findings are applicable to both genders without significant demographic bias. The similarity in gender proportions between groups supports the internal validity of the study by minimizing confounding influences related to demographic variability (Table 1).

Table 1. Demographic characteristics

Variable	RSRLAPB (n=30)	FRC (n=30)
Male	19 (63.3%)	18 (60%)
Female	11 (36.7%)	12 (40%)

The gender-wise distribution of participants in both the RSRLAPB and Functional Range Conditioning (FRC) groups is illustrated in Figure 1 to provide an overview of sample characteristics.

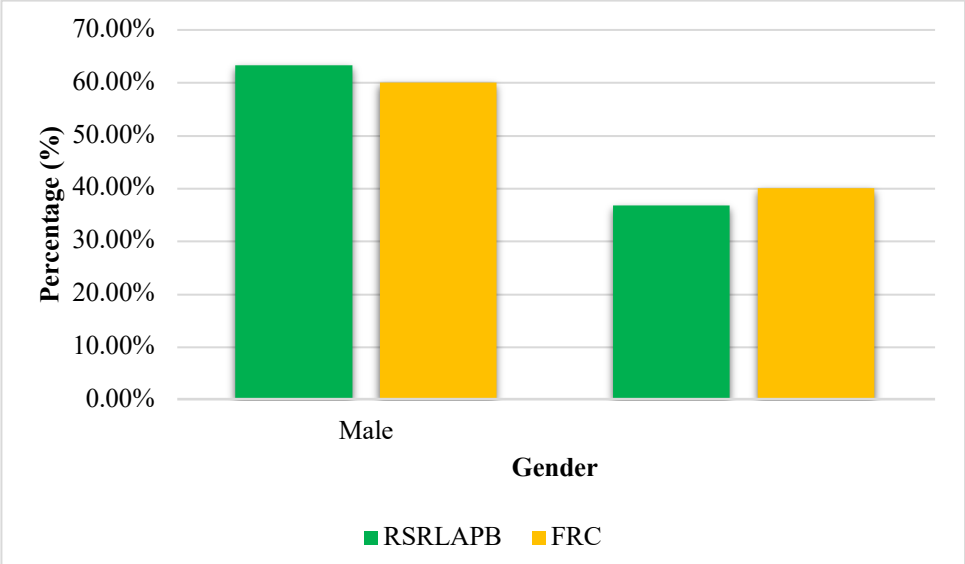

Figure 1. Gender Distribution of Participants in RSRLAPB and FRC Groups

As shown in Figure 1, both groups demonstrated a similar gender distribution, with a marginal predominance of male participants compared to females. This comparable distribution indicates that gender-related bias between the groups was minimal.

3.2 Descriptive Statistics

The results from the descriptive analysis were positive for all measured outcomes in both groups during the 6 weeks of intervention. Both intervention groups showed improvements in hip joint range of motion, muscle strength of the gluteus medius muscles, functional capacity, and single-leg dynamic control. Importantly, the degree of improvement seemed to be higher in the FRC group, implying a significant effect not only on mechanical but also on functional stability of the hip joint. The evidence suggests that, despite being effective interventions, FRC seems to have a larger impact on multiple aspects of hip joint stability (Table 2).

Table 2. Pre- and post-intervention descriptive statistics

Variable	Group	Pre Mean ± SD	Post Mean ± SD
Hip Adduction ROM (°)	RSRLAPB	9.27 ± 1.55	12.47 ± 1.94
	FRC	9.27 ± 1.55	14.80 ± 2.89
LEFS	RSRLAPB	49.43 ± 10.21	61.10 ± 7.97
	FRC	50.33 ± 9.94	70.03 ± 7.03
Strength (N)	RSRLAPB	125.57 ± 10.07	137.43 ± 8.87
	FRC	126.40 ± 10.16	153.87 ± 10.75
SLS	RSRLAPB	2.90 ± 0.71	1.70 ± 0.65
	FRC	2.90 ± 0.71	0.70 ± 0.65

The comparison of pre- and post-intervention mean values for hip adduction ROM, LEFS, gluteus medius strength, and SLS in both groups is presented in Figure 2.

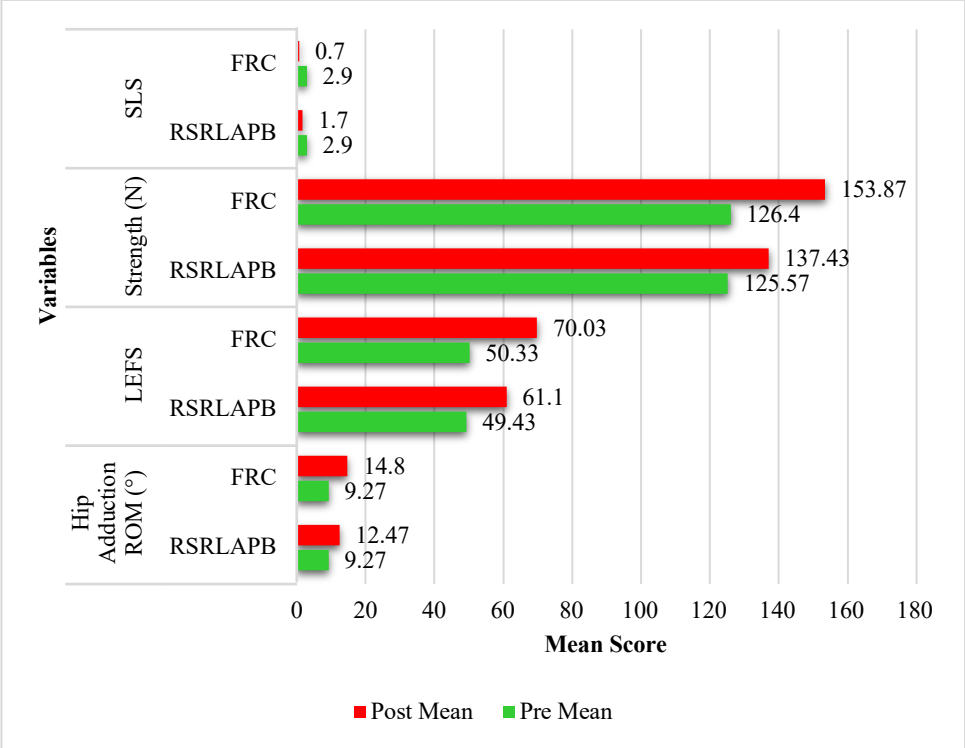

Figure 2. Pre- and Post-Intervention Comparison of Outcome Measures

As illustrated in Figure 2, both groups showed improvement across all variables following the intervention; however, the FRC group demonstrated greater gains in ROM, strength, and functional performance, along with a more pronounced reduction in SLS scores compared to the RSRLAPB group.

3.3 Within-Group Analysis

Group-level results showed statistically significant positive changes for all parameters measured within both experimental groups, thus demonstrating the efficacy of both the RSRLAPB and FRC methods in managing iliotibial band tightness and related functional issues. Positive changes were seen in terms of joint flexibility, muscle strength, functional performance, and dynamic stability, proving that both types of exercises had beneficial effects on multiple aspects of function. Nevertheless, the magnitude of the change was always greater in the FRC group, implying that interventions utilizing end-range loading and progressive strength training might yield better outcomes (Table 3).

Table 3. Within-group comparison

Variable	Group	Mean Change ± SD	t-value	p-value
ROM (°)	RSRLAPB	3.20 ± 1.35	12.99	<0.001
	FRC	5.53 ± 2.61	11.61	<0.001
LEFS	RSRLAPB	11.67 ± 5.01	12.77	<0.001
	FRC	19.70 ± 7.07	15.26	<0.001
Strength (N)	RSRLAPB	11.87 ± 4.20	15.48	<0.001
	FRC	27.47 ± 7.69	19.56	<0.001
SLS	RSRLAPB	-1.20 ± 0.61	-10.77	<0.001
	FRC	-2.20 ± 0.61	-19.75	<0.001

The mean changes in outcome measures following the intervention for both the RSRLAPB and FRC groups are illustrated in Figure 3.

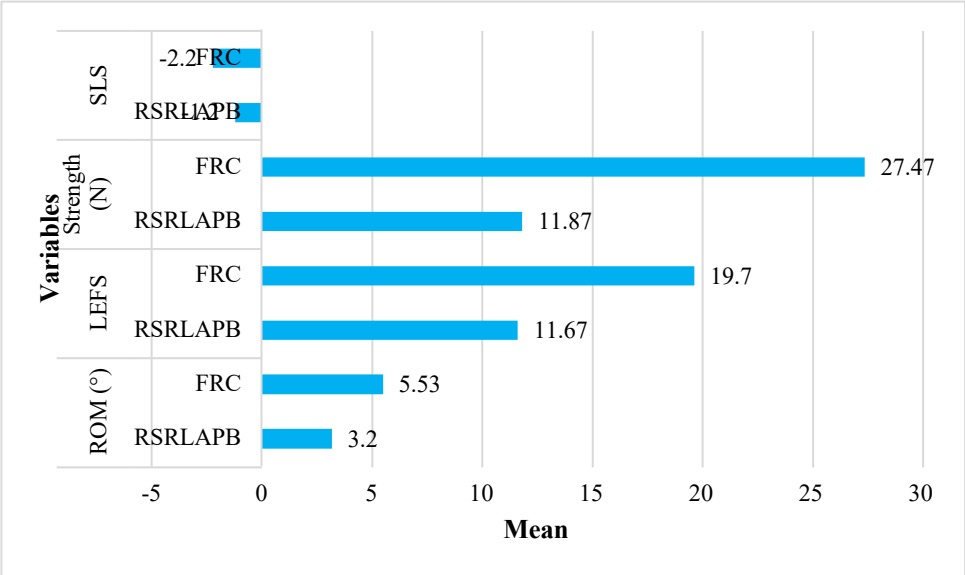

Figure 3. Comparison of Mean Changes in Outcome Measures Between Groups

As shown in Figure 3, the FRC group demonstrated greater improvements across all variables compared to the RSRLAPB group, particularly in gluteus medius strength and functional performance, along with a larger reduction in SLS scores, indicating enhanced dynamic hip stability.

3.4 Between-Group Analysis

Between-group comparison indicated that the improvements noted in the FRC group were significantly higher compared to the RSRLAPB group in terms of all the outcome measurements. It was noted that despite both the exercises being beneficial, the FRC technique provided better results with regards to improvement in the flexibility of hips, strength of gluteus medius, functional capacity, and dynamic stabilization. It appears that FRC offers a better effect on both the functional and structural aspects of lateral hip stabilization, rendering it a better option for distance runners (Table 4).

Table 4. Between-group comparison

Variable	RSRLAPB Mean ± SD	FRC Mean ± SD	t-value	p-value
ROM (°)	3.20 ± 1.35	5.53 ± 2.61	-4.35	<0.001
LEFS	11.67 ± 5.01	19.70 ± 7.07	-5.08	<0.001
Strength (N)	11.87 ± 4.20	27.47 ± 7.69	-9.75	<0.001
SLS	-1.20 ± 0.61	-2.20 ± 0.61	6.35	<0.001

3.5 Correlation Analysis

Correlation analysis showed significant correlations between all tested parameters, emphasizing the dependence of each other. The strong correlation coefficient between the strength of the gluteus medius and functional skills implies that any improvement in the muscles' power will positively impact functional capabilities in everyday and sports actions. Furthermore, the negative correlation between the hip mobility and SLS points proves that greater joint flexibility leads to increased balance and coordination in dynamic activities (Table 5).

Table 5. Correlation analysis

Variables	r-value	p-value
Strength vs LEFS	0.959	<0.001
ROM vs SLS	-0.310	0.016

3.6 Regression Analysis

The regression analysis provided additional support for the role of critical variables in predicting certain results, showing that strength of the gluteus medius muscle was a major predictor of functional performance, and hip abduction range of motion had an impact on dynamic stability results. This indicated that strength improvement and joint range of motion could be significant factors in improving functionality in isolation, offering a solid rationale for improvements observed among both samples (Table 6).

Table 6. Regression analysis

Dependent Variable	Predictor	β	p-value
LEFS	Strength	0.652	<0.001
SLS	ROM	-0.094	0.016

4. DISCUSSION

The current research was done to compare the efficacy of Right Sidelying Respiratory Left Adductor Pull Back (RSRLAPB) and Functional Range Conditioning (FRC) exercise in the treatment of iliotibial band tightness, gluteus medius weakness, and lateral hip instability among long-distance runners. The results showed that the two interventions resulted in great changes in hip adduction range of motion (ROM), gluteus medius strength, functional ability, and dynamic stability. Nevertheless, the FRC group has always had more improvements in all outcome measures, which is evidence of its higher effectiveness in dealing with the multifactorial impairment of lateral-hip instability. The biomechanical and neuromuscular deficits in runners are crucial because of the observed enhancements in both groups when using specific rehabilitation measures. The main types of exercises taught during RSRLAPB include pelvic repositioning, breathing, and neuromuscular re-education, which probably played a role in better motor control and alignment. This, in turn, could have decreased the compensatory loading on the iliotibial band and enhanced movement efficiency. Conversely, FRC focuses on end-range mobility, strength gains, and joint-specific control, which could be the reason behind more significant changes in ROM and muscle strength. The mobility gains and strength gains probably contributed to the power of the subjects to stay stable in the process of dynamic activities, which were manifested in the better performance of Single Leg Squat (SLS). The high positive relationship between the strength of gluteus medius and functional ability (LEFS) further validates the importance of hip abductor strength in enhancing lower extremity functioning. In the same way, there was a negative correlation between ROM and SLS scores indicating that the higher the hip mobility, the greater the dynamic stability. These results were confirmed through regression analysis, which showed that strength and ROM are important predictors of functional performance and stability outcomes, which means that both of these factors are crucial elements in rehabilitation.

The results are in line with the existing literature that has highlighted the effectiveness of conservative rehabilitation interventions in iliotibial band syndrome. Systematic review by Miccio et al. [19] emphasized the effectiveness of exercise-based interventions especially those based on strength and flexibility in reducing symptoms and enhancing functions in people with ITB syndrome. On the same note, Christopher et al. [20] noted that muscle strength and range of motion deficits are important predictors of lower extremity injuries in runners, which justify the need to manage them in rehabilitation programs. Moreover, new evidences indicate that exercise-based interventions can prevent and manage running related injuries. Wu et al. [21] also showed that the risk of injury in endurance runners is greatly reduced by structured exercise interventions, and strength and neuromuscular training have a significant influence on the injury risk. Another study by Toresdahl et al. [22], is also a randomized study study which found that strength training programs are effective in reducing the occurrence of injuries among marathon runners, thus strengthening the need to include strengthening exercises in training programs. Moreover, Linton et al. [23] noted that effective injury prevention initiatives should be multi-factorial, addressing various risk factors, such as mobility, strength, and neuromuscular control. This is in line with the results of the current study, in which the FRC approach, which incorporates these elements, led to better results. Likewise, Balsalobre-Fernandez et al. [24] indicated that muscle performance is not the only benefit of strength training, it also serves to increase the efficiency of running meaning that it has a wider performance effect than injury prevention.

The clinical implications of this research are great to the physiotherapists, sports clinicians, and trainers who handle long-distance runners. These findings indicate that, although both RSRLAPB and FRC could be integrated into the rehabilitation program, FRC could be a more holistic intervention that could involve mobility, strength, and neuromuscular control. This renders it especially useful with athletes who have multiple

impairments, including tightness in the ITB and weakness of the gluteus medius. Such interventions can also be incorporated in the regular training routines with the view that they could prevent recurrence and enhance overall performance.

Although it has its strengths, this research is limited in some way. The sample size was also sufficient but was also restricted to a given population of runners in one geographic area, which can have an impact on the external validity of the results. Also, the research was based on the clinical outcomes, including SLS to evaluate the stability in the dynamic aspect instead of using biomechanical analysis, which can be more detailed. The time of intervention is rather also not long and restricts the possibility of long-term outcomes and sustainability of the improvements.

Further studies are needed on larger and more heterogeneous groups in the future to increase the external validity. Longitudinal research is required to determine the long-term outcomes of this intervention on preventing injury and performance. The use of sophisticated biomechanical measurements and muscle activation analysis would allow gaining a better understanding of the mechanism of improvements. Moreover, the integration of RSRLAPB and FRC can be considered to find out whether an integrated rehabilitation protocol results in even more advantages.

5. CONCLUSION

The current research compared and contrasted the efficacy of Right Sidelying Respiratory Left Adductor Pull Back (RSRLAPB) exercise and Functional Range Conditioning (FRC) on the iliotibial band tightness, gluteus medius weakness, and lateral hip instability in long-distance runners. The results showed that the two interventions were effective in causing significant changes in the hip adduction range of motion, the gluteus medius strength, functional ability, and dynamic stability after a 6-week period of intervention. Nonetheless, the extent of the improvement was always higher in the FRC group in all the outcome measures. Participants receiving FRC reported better improvements in joint mobility, muscle strength and functional performance, and a greater change in dynamic hip stability. These findings indicate that the interventions that involve end-range mobility and strength training could offer more holistic neuromuscular and biomechanical advantages than those interventions that emphasize mainly postural and neuromuscular re-education. The paper also demonstrated the close correlation between the strength of the gluteus medius and functional performance and the role of hip mobility in dynamic stability and the need to consider both during rehabilitation programs. All in all, although both RSRLAPB and FRC can help, Functional Range Conditioning seems to be a more helpful intervention in the management of lateral hip instability among long-distance runners, as it is a holistic intervention that helps to address the underlying impairment and provide better functional outcomes.

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