Optimizing Hip Function in Collegiate Baseball Pitchers Through Pilates Training
by

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Introduction

The overall research problem addressed in this literature review is the effectiveness of Pilates training in improving bilateral hip range of motion and strength during pitching in collegiate baseball players. Baseball pitching requires a combination of upper and lower body movements, with the hip joint playing a crucial role in generating power and transferring force. Therefore, enhancing the hip range of motion and strength can improve pitching performance and injury prevention.

Statement(s) of Clinical Relevance

It is essential to understand the effects of Pilates training on hip range of motion and strength in collegiate baseball players for various clinical reasons. First, baseball pitchers often experience hip-related injuries and restrictions in their range of motion, which can negatively affect their performance and overall well-being (KW, 2015). By identifying effective interventions such as Pilates training, clinicians and coaches can implement targeted strategies to optimize hip function and reduce the risk of injuries in this population (KW, 2015). Additionally, enhancing hip range of motion and strength may improve pitching mechanics, velocity, and accuracy, critical factors for success in collegiate baseball (Orishimo et al., 2023).

Furthermore, Pilates training offers a holistic approach to conditioning and rehabilitation, emphasizing core stability, flexibility, and proper movement patterns (Phrompaet et al., 2011). Incorporating Pilates into the training regimen of collegiate baseball players can potentially improve hip function and enhance overall physical fitness and injury resilience. Therefore, investigating the effects of Pilates training on hip range of motion and strength in this specific population holds clinical significance and can provide valuable insights for sports medicine

professionals, coaches, and athletes (KW, 2015).

Summary of Background

The available literature on the effects of Pilates training on hip range of motion and strength in collegiate baseball players is currently lacking. However, researchers have explored related aspects, such as trunk stability, throwing velocity, and biomechanics, in the context of baseball pitchers (Orishimo et al., 2023). While these studies do not directly investigate Pilates training, they offer valuable insights into the significance of hip function and its correlation with pitching performance.

Pilates regimens have garnered recognition as effective health enhancement, rehabilitation, and athletic conditioning interventions. Harrington and Davies' investigation supported the assertion that Pilates techniques yield enhancements in trunk stability (Harrington & Davies, 2005). The study outcomes propose that integrating the Pilates method into an exercise routine can be a complementary program to enhance flexibility and promote better control and mobility of the trunk and pelvic segments (Phrompaet et al., 2011). Furthermore, it may aid in the prevention and reduction of injuries and dysfunctions in the musculoskeletal system (Phrompaet et al., 2011).

Another study compared the effects of static stretching and Pilates interventions on flexibility among older women (Oliveira et al., 2016). The randomized controlled trial recruited older women over 60 and assessed flexibility using a fleximeter (Oliveira et al., 2016). Both groups showed improvements, with Pilates demonstrating superiority in trunk extension movement flexibility (Oliveira et al., 2016). This highlights Pilates' efficacy in enhancing flexibility and supporting functional independence in older adults (Oliveira et al., 2016).

Findings from studies on trunk stability are particularly relevant, as a stable trunk is essential for efficient energy transfer from the lower body to the upper body during pitching (Aguinaldo & Nicholson, 2021). The hip joint plays a critical role in generating power for pitching motion, so the connection between trunk stability and hip function underscores the potential impact of Pilates training, which emphasizes core strength and stability, on pitching performance.

Additionally, research examining throwing velocity provides valuable context for understanding the role of hip strength, flexibility, and mobility in pitching mechanics (Zipser et al., 2021). A robust and stable hip joint contributes to a more forceful and efficient pitching motion, increasing throwing velocity. While these studies do not explore the direct link to Pilates training, enhancing hip strength through Pilates exercises may positively influence throwing velocity.

Furthermore, insights from studies examining the effects of Pilates training on other populations, such as youth athletes and individuals with musculoskeletal conditions, provide relevant information on improving range of motion and strength (Park et al., 2020). As the hip range of motion and strength are crucial for optimal pitching performance, these studies indirectly suggest the potential benefits of Pilates exercises in collegiate baseball players for enhancing hip function during pitching.

Despite the wealth of literature on the significance of hip function in pitching performance and the potential advantages of Pilates training for related factors, there exists a considerable research gap concerning the direct impact of Pilates on hip range of motion and strength in collegiate baseball pitchers. This limitation highlights the need for targeted research that specifically investigates the effects of Pilates training on hip function during pitching in this

population. By addressing this gap, the proposed study aims to contribute to the current knowledge on the benefits of Pilates for hip function in collegiate baseball players, further informing the development of evidence-based training protocols for improving pitching performance and reducing the risk of hip-related injuries.

Further investigation is necessary to comprehensively understand how Pilates training affects the bilateral hip range of motion and strength during pitching in collegiate baseball players, such as clinical dynamometric, ROM tests, and motion analysis. This literature review aims to synthesize the existing research, critically evaluate the methodologies and findings, and identify gaps in the current knowledge. Doing so will lay the groundwork for a research proposal that will contribute to advancing our understanding of the role of Pilates training in enhancing hip function and performance in collegiate baseball players.

Researchers have gained valuable insights into the relationship between Pilates training and pitching performance, but it is vital to consider certain limitations. Firstly, a substantial portion of the reviewed studies focused on specific aspects of pitching mechanics or included populations other than collegiate baseball players (Laudner et al., 2015). While these studies offer valuable information, the direct investigation of Pilates training's effects on hip range of motion and strength during pitching in collegiate baseball players is relatively limited. It is essential to conduct research explicitly targeting collegiate baseball players to understand the potential benefits of Pilates for their hip function during pitching, as they have unique biomechanical demands and training requirements.

Secondly, some studies had relatively small sample sizes, which may impact the generalizability of their findings to a broader population (Zipser et al., 2021). Larger sample sizes are crucial for obtaining more robust and representative results.

These critiques emphasize the need for more focused investigations that specifically address the impact of Pilates training on hip range of motion and strength during pitching in collegiate baseball players. The proposed study utilizes validated assessment tools and focuses on college baseball players participating in a 4-week Pilates training program to overcome these limitations. By doing so, this research aims to fill the gap in the current literature and provide more comprehensive and generalizable insights into the effects of Pilates training on hip function in this specific population.

Despite the extensive research on related aspects, there remains a significant gap in the literature regarding the effects of a 4-week Pilates training program on bilateral hip range of motion and strength during pitching in collegiate baseball players. While some studies indirectly suggest the potential benefits of Pilates training on hip function, more comprehensive research is needed to target this population. Furthermore, studies have focused on upper limb and trunk biomechanics in pitching, overlooking the critical role of the lower body, particularly the hip joint, which is essential for generating power and force during pitching (Downs et al. 2021).

Recent investigations have highlighted the intricate relationships between physical limb characteristics, elbow kinetics, and elbow kinematics in youth baseball pitchers (Downs et al., 2021). This study revealed significant associations between upper arm length and forearm-to-upper arm ratio with elbow kinetics, providing valuable insights into the mechanisms contributing to elbow loading and injury risk.

While this research enhances our understanding of upper limb biomechanics during pitching, it underscores a notable gap in the literature regarding the role of the lower body, particularly the hip joint, in pitching motion. The hip joint is pivotal in generating power and force during pitching, yet it has often been overlooked in biomechanical analyses (Naito et al.,

2012). Therefore, future studies should investigate the contributions of the lower body biomechanics, including the hip joint, to provide a more holistic understanding of pitching mechanics and injury prevention strategies.

The identified gap in the available data justifies the need for a systematic investigation into the effects of Pilates training on hip range of motion and strength in collegiate baseball players to provide a comprehensive understanding of how this training modality can enhance pitching performance and reduce the risk of hip-related injuries. The necessity for more specific studies examining Pilates training's impact on hip range of motion and strength in collegiate baseball pitchers highlights the research gap this proposed study aims to address.

Purpose of the Study

This study aims to investigate the effects of a 4-week Pilates training program on bilateral hip range of motion and strength during pitching in collegiate baseball players. While previous research has explored the relationship between Pilates training, core stability, and pitching mechanics, this study focuses specifically on the influence of Pilates exercises on hip function.

The study intends to assess the effects of Pilates training on hip range of motion and strength in collegiate baseball pitchers through a 4-week training intervention. The duration of the training program has been strategically chosen to allow sufficient time for potential adaptations to occur. Additionally, the study will comprehensively analyze bilateral hip range of motion and strength, providing a thorough understanding of hip function during the pitching motion.

Moreover, the research builds upon previous findings suggesting a link between core stability and pitching performance. As Pilates training emphasizes core strengthening, improvements in core stability may positively impact hip function during pitching. By

investigating the direct effects of Pilates exercises on hip range of motion and strength, the study aims to provide evidence supporting the use of Pilates as a targeted intervention for enhancing hip function in collegiate baseball pitchers.

Overall, the study seeks to address the identified gap in the literature by providing new insights into the potential benefits of Pilates training for baseball pitchers, with implications for optimizing pitching mechanics, reducing the risk of hip-related injuries, and improving overall pitching performance. This research will offer valuable insights for sports medicine professionals, coaches, and athletes, supporting evidence-based decision-making in designing training programs for collegiate baseball players.

Hypothesis

It was hypothesized that a 4-week Pilates training program would likely improve bilateral hip range of motion and strength during pitching in collegiate baseball pitchers. Based on the existing literature indicating the potential benefits of Pilates training for core stability, lumbar range of motion, and overall athletic performance, it is expected that the targeted Pilates exercises will enhance hip function, ultimately leading to improved pitching mechanics, velocity, and accuracy in the participating collegiate baseball players.

Methods

Participants

The study recruited collegiate baseball pitchers aged 18-25 with no prior experience in Pilates and no history of hip injuries. This ensured a homogeneous sample of participants with similar athletic backgrounds and hip health status. Despite the limited number of participants, three pitchers provided written informed consent to participate in this study, which was approved by the university's institutional review board.

Intervention

During the intervention phase, participants engaged in a 4-week Pilates training program consisting of two 50-minute weekly sessions. The Pilates sessions focused on exercises targeting hip strength and mobility, including footwork, Climbing Tree, Abdominals with Legs in Straps, Bridge, Short spine, Standing Lunges, Side Split, Mermaid, Feet in straps, and Side-lying foot in the strap. These exercises were designed to strengthen hip extensors and flexors, develop pelvic-lumbar stabilization, improve abdominal muscle control, increase the flexibility of the lower back and hamstring, and enhance mobility in abduction and adduction. Additionally, to ensure comprehensive training, participants utilized a Reformer apparatus, a key component of Pilates equipment known for its versatility in targeting various muscle groups, including those around the hips.

Data Collection

Before and after the intervention, the participants' hip range of motion (ROM) and strength were evaluated using force-sensing assessment tools. The evaluator had received prior training on utilizing established assessment tools to assess participants' range of motion and had conducted practice assessments on non-study participants before the current study commenced. This comprehensive assessment encompassed various movements, including hip flexion/extension, abduction/adduction, and internal/external rotation. Measurements were taken to determine the maximum force exerted during these movements, quantified in Newtons, and the degree of angle achieved, measured in degrees. A handheld force sensing unit known as the Vald Dynamo (VALD Performance, Australia) was utilized to facilitate accurate data collection. This sophisticated device enabled the precise measurement of maximum force output, degree of

angle during movement, and any potential asymmetry between the hips, providing valuable insights into participants' hip function and possible areas of improvement.

Measurement Setup

The measurement setup encompassed the evaluation of maximum force for hip abduction, adduction, flexion, extension, and internal and external rotation. Participants were positioned supine with legs extended for abduction and adduction measurements. The dynamo was placed on the lateral side of the ankle to assess adductor strength and on the medial side for abduction strength. Participants maintained their legs at a 90° angle for internal and external rotation measurements, with the unit applied from the lateral side for internal rotation and from the medial side for external rotation. Flexion and extension measurements were conducted with participants standing while the force unit was applied downward on the knee for flexion strength and forward on the hamstrings for hip extension. Participants exerted force against the unit throughout all tests to achieve maximum force.

Additionally, the evaluation included the assessment of asymmetry in strength and range of motion. Range of motion (ROM) for internal and external rotation was evaluated with the device secured around the calf, with participants seated and feet hanging. Participants performed heel movements to measure internal rotation (heel pushed laterally) and external rotation (heel pushed medially).

Moreover, hip flexion and extension ROM measurements were conducted with the device secured around the quadriceps, with participants standing and executing hip flexion and extension movements to determine the degree of angle for their ROM.

Data Analysis

Summary statistics were calculated for the bilateral hip ROM and strength measures above. To compare these measures before and after the Pilates training intervention, paired t-tests were employed using open-source statistical software (JASP, ver. 0.17.3) at a significance level of 0.05.

Results:

The study aimed to investigate the effects of a Pilates intervention on hip range of motion and strength. Table 1 illustrates the paired T-Table results from pre and post-intervention assessments for a bilateral hip range of motions, encompassing flexion, extension, abduction, adduction, internal rotation, and external rotation. The outcome measurements for these assessments included a range of motion, quantified in degrees, and strength, measured in newtons (N).

Table 1 *Summary statistics of bilateral hip ROM and strength pre- and post-intervention (n=3)*

Variable	Pre (mean±sd)	Post (mean±sd)	p value
ASYM FLEX ROM (deg)	6.0±7.6	6.8±2.3	0.900
ASYM EXT ROM (deg)	13.7±5.5	13.3±13.5	0.950
ASYM IR ROM (deg)	19.6±16.5	9.3±7.6	0.514
ASYM ER ROM (deg)	11.9±8.7	14.3±4.7	0.784
ASYM ADD STRENGTH (N)	18.4±4.6	17.1±2.8	0.395
ASYM ABD STRENGTH (N)	6.6±6.0	9.9±8.1	0.726
ASYM IR STRENGTH (N)	11.0±6.6	6.1±3.1	0.345
ASYM ER STRENGTH (N)	18.2±12.9	8.7±9.3	0.083
ASYM FLEX STRENGTH (N)	18.9±29.5	7.2±7.9	0.629
ASYM EXT STRENGTH (N)	13.8±11.8	8.8±8.1	0.690
L FLEX ROM (deg)	116.0±11.8	114.7±13.2	0.866
R FLEX ROM (deg)	111.3±10.4	118.7±5.9	0.197

L EXT ROM (deg)	76.0±21.8	69.3±19.9	0.144
R EXT ROM (deg)	74.7±19.0	77.7±10.8	0.644
L IR ROM (deg)	31.7±1.5	38.7±0.6	0.007
R IR ROM (deg)	32.7±11.2	35.3±3.5	0.659
L ER ROM (deg)	37.0±1.0	37.3±4.9	0.918
R ER ROM (deg)	35.7±7.6	40.3±7.6	0.398
L ADD STRENGTH (N)	110.7±45.8	171.3±43.4	0.270
R ADD STRENGTH (N)	133.3±50.6	181.3±38.9	0.446
L ABD STRENGTH (N)	129.3±54.7	174.7±35.9	0.469
R ABD STRENGTH (N)	134.7±59.4	194.3±40.9	0.408
L IR STRENGTH (N)	130.0±66.6	179.7±40.7	0.504
R IR STRENGTH (N)	130.3±69.8	185.3±32.3	0.445
L ER STRENGTH (N)	105.7±61.3	140.0±5.6	0.467
R ER STRENGTH (N)	106.7±65.7	154.0±23.6	0.456
L FLEX STRENGTH (N)	194.3±58.5	210.3±43.8	0.812
R FLEX STRENGTH (N)	169.3±95.7	223.7±27.8	0.525
L EXT STRENGTH (N)	199.3±67.3	262.7±48.1	0.170
R EXT STRENGTH (N)	211.3±70.3	270.3±18.6	0.211

The primary outcome measure, left hip internal rotation, exhibited a statistical improvement following the intervention (Figure 1). Before the intervention, the mean left hip internal rotation was [31.7±1.5] degrees, while post-intervention assessment revealed a notable increase to [38.7±0.6] degrees. This change was significant ($p = 0.007$), indicating a positive effect of the intervention on left hip mobility.

Figure 1 *Comparison of pre- and post-intervention left hip internal rotation ROM (deg), the mean difference of which was statistically significant (p < .01).*

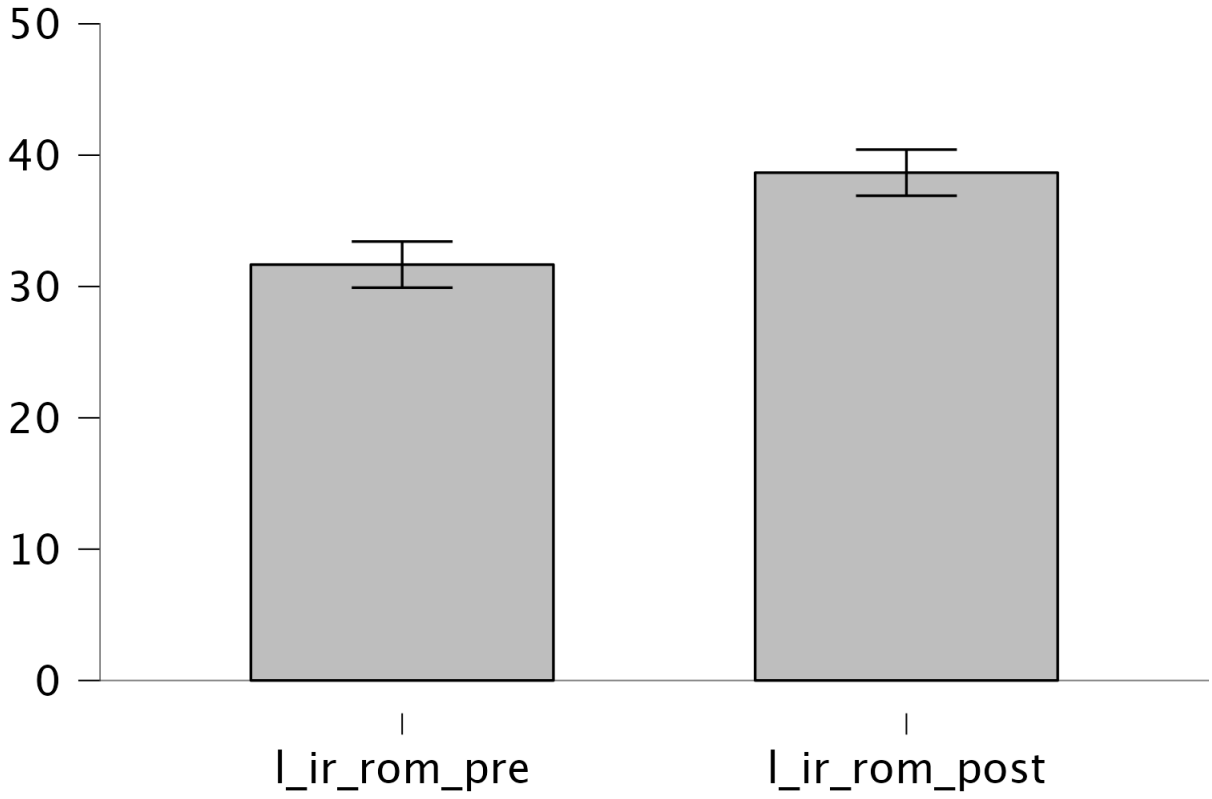
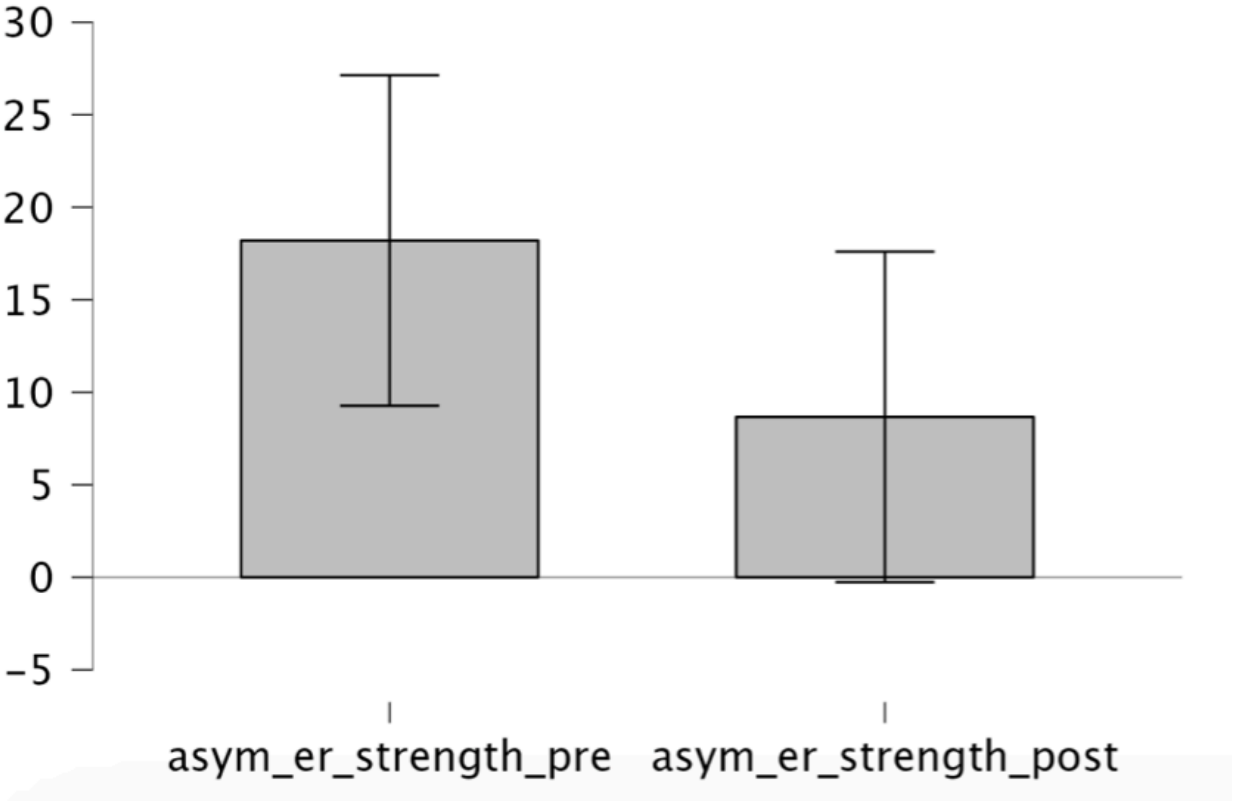


Figure 2 compares bilateral hip strength asymmetry in the external rotation before and after the intervention. Before the intervention, the mean asymmetry in external rotation strength was 18.2±12.9 degrees. Following the intervention, there was a notable decrease in asymmetry, with the mean decreasing to 8.7±9.3 degrees. This indicates that participants exhibited greater symmetry in hip strength in external rotation after the intervention. However, this change did not reach statistical significance (p=0.083), suggesting that while there was a reduction in asymmetries, it was not statistically significant.

Figure 2 *Comparison of pre-and post-intervention asymmetry of external rotation (N).*



Discussion

The improvement in left hip internal rotation indicates that the Pilates intervention effectively targets specific muscle groups responsible for hip mobility, even among collegiate-level athletes. This finding contrasts with initial expectations that these athletes, already highly conditioned, might show minimal improvement compared to average healthy individuals. Thus, the study suggests that Pilates offers notable benefits for enhancing hip mobility in athletes, irrespective of their baseline fitness levels.

Comparing the results with previous research on hip function interventions reveals promising outcomes. Despite the small sample size, the study identifies trends suggesting the

efficacy of Pilates in improving hip mobility among collegiate baseball pitchers. This aligns with findings from studies examining the effects of various interventions on hip function in athletes, indicating that Pilates holds promise as a valuable addition to training regimens aimed at enhancing athletic performance and reducing injury risk.

However, it is essential to acknowledge the study's limitations, notably the small sample size and the brief intervention period. The limited number of participants, consisting of only three collegiate baseball pitchers, raises concerns about the generalizability of the findings. Future research endeavors should prioritize recruiting more extensive and diverse samples to enhance the external validity of the results.

Moreover, the short duration of the Pilates intervention, lasting only four weeks, may have constrained the magnitude of observed changes in hip mobility and strength. Extending the intervention period could yield more substantial improvements and offer a more comprehensive understanding of Pilates' effects on hip function among collegiate athletes.

Another noteworthy aspect is the pitchers' heightened awareness of their form before and after the intervention. Following the Pilates sessions, pitchers demonstrated hip movement with diminished compensatory actions in other areas of their bodies, indicating a more focused engagement of the targeted muscle groups. This reduction in compensatory movements suggests that the Pilates intervention facilitated a more efficient execution of hip movements, potentially leading to minimal improvement in overall performance.

Moving forward, researchers should explore whether the timing of Pilates interventions, such as during the off-season versus in-season, influences the magnitude of athletes' improvement in hip mobility. Additionally, investigating the potential synergistic effects of combining Pilates with other training modalities commonly used during off-season or in-season

training programs could provide valuable insights into optimizing athletic performance and minimizing injury risk.

Addressing these limitations and pursuing future research will contribute to a more nuanced understanding of Pilates training's effects on hip function in collegiate baseball players. Conducting larger-scale studies with longer intervention periods and exploring various intervention strategies will further elucidate Pilates's potential benefits for enhancing hip mobility and overall athletic performance in this population.

Practical Implications

The findings of this study have practical implications for clinicians, coaches, and athletes involved in collegiate athletics. The demonstrated effectiveness of Pilates interventions in improving hip mobility among collegiate-level athletes offers actionable insights for enhancing athletic performance and reducing injury risk in real-world settings. Clinicians can utilize Pilates-based exercises as part of rehabilitation programs for baseball pitchers recovering from hip injuries, facilitating a quicker return to play and reducing re-injury risk.

Coaches have the opportunity to integrate Pilates training into the regular conditioning regimens of collegiate baseball players, thereby optimizing hip function and overall athletic performance. Pilates exercises, targeting specific muscle groups responsible for hip mobility, can improve pitching mechanics, velocity, and accuracy, ultimately contributing to more tremendous success on the field. Athletes can also benefit from Pilates training to enhance their physical conditioning and resilience, maximizing their potential for success in collegiate baseball.

Conclusion

In conclusion, this study highlights the significant impact of Pilates interventions on hip mobility among collegiate baseball pitchers. Contrary to initial expectations, the findings

demonstrate that Pilates training can potentially effectively target specific muscle groups responsible for hip function, leading to improved mobility even among athletes with heightened physical conditioning. By exploring Pilates interventions' timing and synergistic effects, the research provides valuable insights for optimizing athletic performance and reducing injury risk in collegiate baseball.

In summary, the study contributes to the growing body of evidence supporting the efficacy of Pilates training in enhancing hip function and overall athletic performance in collegiate baseball players. Emphasizing tailored exercise programs that address athletes' needs, the research offers practical recommendations for clinicians, coaches, and athletes seeking evidence-based strategies to optimize performance and promote player well-being in collegiate baseball. Ultimately, the findings underscore the importance of integrating Pilates training into collegiate athletes' conditioning regimens, leading to enhanced performance and success on the field.

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