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Enhancement of Hip Joint Flexibility using Flexor and Unilateral Exercises

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ABSTRACT: *Improved hip flexibility is essential for enhanced overall fitness, ensuring balance and a broader range of motion. Therefore, the understanding of how limited hip movement and physical activity can affect performance and increase injury risk due to a lack of flexibility. Thus, this investigation determined the effectiveness of interventions, namely Flexor and Unilateral Exercises, in enhancing the hip-joint flexibility of the participants. The study involved 86 males and 80 females aged 15 to 18, utilizing a two-factor pretest-posttest quasi-experimental research design. Results indicated a significant difference in the pretest and posttest hip joint flexibility of the two groups, Flexor and Unilateral. Post-interventions, significant improvements in hip joint flexibility were evident in both groups. Additionally, the result revealed a noteworthy difference with a significant effect size between pretest and posttest flexibility measures for both the Flexor and Unilateral groups, emphasizing the effectiveness of each intervention. Notably, hip Flexor exercises yielded a considerably higher increment in hip range of motion compared to Unilateral exercises, indicating their superior impact. The two interventions distinctively and significantly enhanced hip joint flexibility, warranting further investigation into the nuances of hip joint range of motion and overall flexibility across genders. This exploration should include a thorough assessment of the intervention's efficacy for both men and women.*

KEYWORDS*:* flexor, unilateral, range of motion, hip joint flexibility, and quasi-experimental.

INTRODUCTION

Hip joint flexibility plays a crucial role in dancing as it allows performers to execute a wide range of movements and techniques. The hip is a critical component of human motion and is essential for a variety of movements, from the simple act of walking to the complex choreography and it plays an important role in facilitating movement which allows performers to move with grace, power, and agility (Segal, 2022; MSc, 2023; TeachMeAnatomy; 2022). However, insufficient hip

joint flexibility can result in pain, stiffness, and restricted mobility, which can affect performance (Tilinger et al., 2021; Teichmann, 2021). This is often due to the sedentary lifestyle, lack of stretching and exercise, as well as poor posture (Ryu & Kim, 2020). Therefore, the study of interventions that enhance range of motion (ROM) is a critical area of research in the field of Physical Education.

Consequently, a full range of motion improves the joints' muscle stability, proper muscle activation, and optimal physical function (Delitzsch & Goebel, 2020). The benefits of a complete range of motion include improved posture through alignment of the spine and joints (American College of Sports Medicine, 2015). It may assist in lowering the likeliness of experiencing injuries (Malone and Brody, 2023). The researcher's observation of young adults' highlights that enhancing range of motion encounters obstacles in school settings where prolonged sitting and seatwork can result in muscle and joint stiffness, leading to discomfort and limited ROM. This restriction in ROM is often attributed to the shortening and tightening of hip muscles and tendons when they are not regularly engaged (Nelson, et. al., 2019). Additionally, prolonged inactivity leads to the degeneration of muscles and joints, resulting in a decrease in the range of motion (Park et. al., 2020). Thus, this necessitates to implementation of interventions aimed at enhancing the range of motion in the hip joints.

The researcher evaluated two exercises, identified through a thorough literature review, as potential means to enhance hip joint flexibility. These exercises, namely Flexor Exercises and Unilateral Exercises, have demonstrated promise in improving hip joint range of motion (Amy, 2022; Greg, 2023).

Flexor Exercises, as identified by Kimberly (2022), are targeted stretches designed to enhance flexibility and mobility in the hip flexors. Laferrara (2022) further recognizes these exercises as integral to a comprehensive lower-body workout regimen. Myers (2019) highlights their importance in boosting mobility and stability, as well as in preventing injuries within the hip area. Moreover, Myers (2019) suggests that these exercises can reduce discomfort in the hip and lower back while also enhancing sports performance. Research by Youdas et al. (2018) corroborates this, demonstrating that a hip flexor stretching program can significantly improve hip joint flexibility and reduce muscle stress in the hip flexors. Furthermore, Taube et al. (2019) explain that neuromuscular control, which is the integration of sensory and motor systems, plays a vital role in facilitating unconscious reactive and adaptive processes for maintaining joint stability during static and dynamic movements.

Given the extensive studies highlighted, the researcher determined the importance of engaging participants in a meticulously chosen set of hip flexor exercises for a quarter of a semester. In this study, selected Hip Flexor Exercises, tailored to optimize efficacy, will be administered to all participants for the entire duration of this quarter-long period. This approach ensures that each

participant consistently performs these strategically selected exercises, allowing for a comprehensive evaluation of their impact over the specified timeframe.

The second intervention in this study, Unilateral Exercises, focuses on engaging specific muscles, rectifying imbalances, and boosting stability and coordination through exercises executed one limb at a time, as outlined by Grgich et al. (2019). These exercises have been established as effective in enhancing the body's muscular strength and addressing size imbalances, according to Botton et al. (2019).

Furthermore, Zhang and colleagues (2023) found that Unilateral workouts stimulate more muscle fibers and increase muscular activation compared to bilateral activities, a factor linked to greater improvements in muscular strength and growth as noted by Folland et al. (2014). Behm et al. (2019) also emphasize the significance of muscle length and flexibility in maintaining optimal physical health and preventing injuries during physical activities, underscoring the potential benefits of these exercises.

Considering the significant research mentioned, participants in this study engaged and completed a series of carefully selected Unilateral Exercises throughout the second quarter of the semester. This approach allowed for a focused assessment of the effect of Unilateral Exercises, as supported by the substantial literature on their benefits.

Moreover, a significant gap apparent in the presented literature is the absence of specific data or research studies that investigate the effectiveness of the proposed interventions—hip Flexor exercises and Unilateral exercises—in the context of enhancing hip joint flexibility for dance performance. While the narrative emphasizes the importance of hip joint flexibility and the potential benefits of these exercises, it lacks substantial empirical evidence or studies that can validate their effectiveness within the specialized domain of dance.

This study, recognizing an essential gap in the empirical understanding of hip flexibility's role in dance performance, aims to rigorously assess the effect of specific interventions on hip joint flexibility. As both a dance instructor and physical education teacher, the researcher understands that improved hip flexibility not only enhances dance performance but also benefits sports and daily activities. By facilitating easier movement, increased hip mobility broadens participation in social activities and sports, while also improving posture and body awareness. Consequently, the ultimate goal of this study is to apply these targeted interventions to notably enhance dance performance through improved hip flexibility.

Framework

This study assumes that flexor and unilateral exercises are two potent interventions in improving hip joint flexibility. This assumption is anchored on the Neuromuscular and Muscle Activation Theory and the concepts of Muscle Length and Flexibility. The theory of Neuromuscular and

Muscular Activation is the nervous system's capacity to activate and coordinate muscle contraction during movement (Janda, 1960), while Muscle length and flexibility dictate that a muscle must be elongated to its ideal length to generate maximum force and power (Myers, 2014).

The interplay between Neuromuscular and Muscle Activation underscores the intricate relationship between the nervous system and the muscular system, crucial in generating and controlling movement (Mulla et. al., 2023). The nervous system activates and coordinate muscle contractions through a network of neurons, where the brain transmits electrical signals to muscles, initiating contractions and facilitating movement. This intricate process encompasses Motor Planning, Signal Transmission, Neuromuscular Junction, Muscle Contraction, Coordination, and Control, underscoring the significance of muscle activation patterns and sequencing for efficient movement.

Moreover, Muscle Length and Flexibility, a theory in kinesiology describes the relationship between the length of a muscle and its ability to stretch facilitates range of motion, reduced risk of injury, and improved performance. Myers (2014) proposed that muscle flexibility is determined by the length of the muscle fibers, the amount of connective tissue surrounding the muscle, and the viscosity of the muscle fluid. According to Myers (2014), there are several factors that can affect muscle length and flexibility, including age, activity level, and genetics.

Central to this study is the improvement of the Hip joint flexibility which is a crucial element of human mobility, encompassing the range of motion that the hip joint can achieve without causing discomfort or pain (Willy et al., 2019). This flexibility is heavily influenced by the condition of the muscles, ligaments, and the soft tissues surrounding the hip joint (Whitaker et al., 2021).

In this study conducted within the Physical Education class (PE 103: Dance), learners encountered challenges when performing various hip motions and variations in different dance genres. This issue closely aligns with the findings of a study by Goh and Low (2019), which underscored the difficulties dancers face in executing hip motions and isolations across diverse dance genres, including hip-hop and contemporary. These identified learners in their research demonstrated a limited range of motion in their hips, significantly impacting the execution of flexor movements and techniques. Consequently, the objective of this study is to enhance the hip joint flexibility of these respondents, ultimately aiming to improve their overall mobility and the muscular balance they rely on.

Hip joint flexibility plays a pivotal role in enabling a wide array of activities, encompassing exercises, sports, leisure, and dance, largely due to the ball-and-socket structure of the hip joint (Kato et al., 2020). Furthermore, it is vital for maintaining proper posture and balance. Research by Kato and colleagues (2020) has established a connection between restricted hip joint mobility and an elevated risk of falls, particularly among older individuals. Nevertheless, Biaoszewski and

associates (2020) have observed that hip joint flexibility is influenced by various factors, including age, gender, level of physical activity, and musculoskeletal health.

At its core, flexor exercises are rooted in the concept of neuromuscular control and muscle activation, as initially proposed by Dr. Vladimir Janda in 1960. This concept posits that movement coordination involves the intricate interaction between the nervous system and muscles, with muscle activation occurring when force is generated through the activation of muscle fibers by motor neurons (Maffiuletti et al., 2016; Enoka & Duchateau, 2016). Specifically, flexor exercises target the muscle group responsible for hip flexion and the upward movement of the leg toward the body. These exercises serve a dual purpose by preventing hip flexor tightness and weakness while simultaneously addressing issues such as lower back discomfort, hip pain, and potential injuries (Ferber et al., 2010).

In the context of unilateral exercises, the researcher applied the principle of muscle length and flexibility, as elucidated by Thomas Kurz (2003). This principle asserts that muscles function most effectively when they operate within their optimal length-tension relationship. However, the absence of consistent stretching routines can result in muscle shortening, which, in turn, may lead to restricted joint mobility, muscle imbalances, and an elevated susceptibility to strains and other musculoskeletal injuries (Schoenfeld et al., 2016).

To address these concerns, the implementation of appropriate stretching exercises becomes crucial. These exercises aim to lengthen the muscles to their optimal length, thereby enabling the generation of maximum force and power. This aspect holds particular relevance for athletes and individuals who regularly engage in exercise, as both muscle length and flexibility play pivotal roles in attaining peak performance levels and mitigating the risk of injuries (Myers & Scott, 2018). Male and female participants will be separated in both the intervention and data analysis due to known biological differences, potential interaction effects, and to ensure sample homogeneity (West et. al., 1996; Hyde, 2005; Cook, 2005; Greaves & Ritz, 2022).

Therefore, the incorporation of stretching exercises into unilateral exercise interventions is essential because they contribute significantly to the harmonization of muscle length and flexibility, ultimately enhancing overall performance and minimizing the potential for injury.

Subsequently, the two theory-based interventions played a vital role in evaluating their effectiveness in enhancing hip joint ROM, which is crucial for students, especially given their sedentary lifestyle during the pandemic. As a result, investigating hip joint ROM became a critical focus of this research, offering an evidence-based solution to address the reduced physical activity concerns among youth.

Flexor exercises primarily target the group of muscles that are involved in hip flexing and bringing the leg up toward the body. The primary hip flexors are the psoas major and the iliacus, which,

collectively, are often called the iliopsoas (Siccardi et al., 2022). These exercises can help to prevent hip flexor tightness, weakness and cure lower back discomfort, hip pain, and injury (Shahid et. al., 2023), and are potential contributors to diverse musculoskeletal injuries affecting the lower extremities, as noted by several studies (Lynall et al., 2017). Reiman and colleagues (2018) found that including hip flexor activation exercises in a warm-up routine improved hip flexor muscle activation and hip range of motion. In a research conducted by Hewett and team (2017), it was observed that focused neuromuscular training led to notable improvements in proximal biomechanics. These improvements included heightened hip external rotation and moment impulses, increased peak trunk flexion, and diminished peak trunk extension.

The Flexor Exercises are effective stretch strategies in loosening tight hip flexor, extending range of motion, joint position sensation, and balance (Aslan et. al., 2018).
The first exercise used for this strategy is Lunge. This exercise is a lower-body exercise where one leg steps forward and bends while the other leg stays behind (Clark et al., 2014). Lunges are a multi-joint exercise primarily targeting the muscles of the lower body including the hip, and knee joints for mobility (Riebe et. al., 2018). This study also maximizes hip flexor stretch as a secondary exercise.

The second employed exercise targets vital muscles associated with hip flexion, including rectus femoris and iliopsoas (Mayo Clinic, 2022). The extended extension range motion involved in this practice helps lengthen these muscle groups while offering a heightened degree of elasticity in them in due course (Jones & Brown, 2016; Willett et.al, 2017). For the third exercise, the jump lunge enhances power and performance in the lower body by combining plyometric action alongside quadriceps development, hip flexor group, hamstrings, as well as glute (Davies et al., 2015). According to studies (Nadzalan et al., 2017; Choi et al., 2018), jump lunges improved both static and dynamic balance.

Meanwhile, Unilateral exercises are motions performed with only one leg or arm while maintaining a balanced utilization of equal sides of the body, preventing excessive strain or overuse of the dominant side. This approach serves to address muscle imbalances, enhance overall balance, engage the core muscles, mitigate the risk of injuries, and promote effective rehabilitation (Amy, 2018). In this study, participants will undergo three unilateral exercises that will help improve hip joint flexibility which are Bulgarian split squat, Step-ups, and single-leg standing.

Bulgarian Split Squat is a one-legged squat variation in which the rear leg is raised on a bench or a strong chair, focusing more on the quadriceps, hamstrings, and glutes, and has been demonstrated to be excellent at improving lower body strength and muscle activation (Laura Williams, 2022). In the research conducted by Mackery and other (2021) it was highlighted that the Bulgarian split squat is most beneficial in contexts that prioritize hip extension also, a study by Andersen and team (2014) revealed that Bulgarian squat proved beneficial to the antagonist and to some extent to the core muscles.

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The second exercise is the Step-up which is a basic bodyweight workout that targets the quadriceps, hamstrings, including gluteal muscles located in the buttocks Lakowski (2023). Step-up involves stepping onto a raised platform, such as a bench or box, with one foot and then stepping back down to the ground (Campbell, 2023).

Lastly, Single Leg Standing, which is an exercise standing on one leg, airborne calf tucked behind the thigh, keeping eyes closed, with hips and shoulders level (Adrienne, 2018). The glutes, intrinsic foot muscles, and total lower body activation are all targeted by single-leg standing (Britennm, 2021). Prior and others (2014) through their investigation on performing single-leg standing, significant and predictable fluctuations were observed in the activation of hip and thigh muscles.

Objective of the Study

This study attempted to determine effectiveness of the two intervention program namely the Flexor and Unilateral Exercises in addressing tight and weak hip joint flexibility. Figure 1, in the subsequent page, provides a schematic overview of the study. The range of motion (ROM) of the hip joint is the dependent variable. The independent variables, which are the interventions used, are located in the center of the framework.

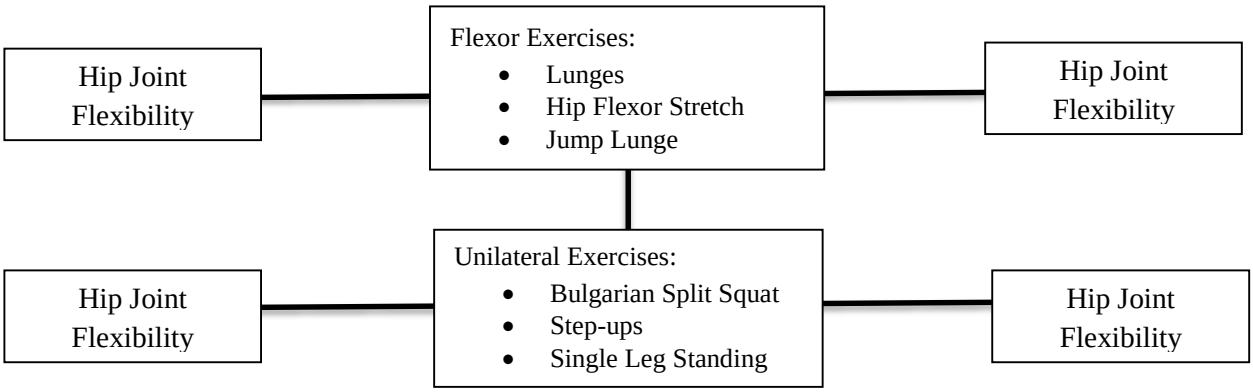

Figure 1: Schematic Diagram of the Interplay of the Variables

METHODS

This study employed a two-factor pretest-posttest quasi-experimental design where a policy or program is seen as an intervention and the treatment consisted of the program/policy getting evaluated - is tested as to how well it reaches its objectives, as measured by a predetermined collection of indicators (White & Sabarwal, 2014). Consequently, quasi-experimental research was used to compare two groups (Trochim, 2001) that includes measuring the outcome variables

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before and after the intervention (Kirk, 1995). According to Maciejewski (2020), quasi-experiments are comparable to randomized controlled trials in many aspects. This study used a quasi-experimental research design to measure the effectiveness of two interventions on two groups of participants, one with males and one with females. This was done to assess the effective of the interventions on the intended participants.

RESULT AND DISCUSSION

Table 1 presents the frequency, percentage, and mean distribution of the male participants' hip joint flexibility before and after the interventions. The data reveal that the initial mean hip joint flexibility for the Flexor Exercises Group was rated as "*good*" at 102.21. Following the intervention, there was a considerable mean increase, reaching an "*outstanding*" level at 142.00. It can be surmised that the Flexor Exercises have improved hip joint flexibility, resulting in a significant and notable increase in flexibility among the participants.

Table 1
Frequency, Percentage and Mean Distribution of the Male Participants' Hip Flexibility Before and After Interventions

Range	Interpretation	GROUP 1 Flexor Exercise				GROUP 2 Unilateral Exercises			
		Pretest		Post Test		Pretest		Post Test	
		F	%	F	%	F	%	F	%
123-156	Outstanding	8	18.6	42	97.7	3	7.0	40	93.0
111-122	Very Good	7	16.3	1	2.3	19	44.2	3	7.0
101-110	Good	6	14.0	0	0.0	6	14.0	0	0.0
92-100	Fair	9	20.9	0	0.0	9	20.9	0	0.0
55-91	Poor	13	30.2	0	0.0	6	14.0	0	0.0
Total		43	100	43	100	43	100	43	100
Mean		102.21		142.00		108.05		136.21	
Interpretation		Good		Outstanding		Good		Outstanding	
SD		16.97		14.01		13.15		11.15	

Such improvement in hip joint flexibility seen among males after engaging in Flexor Exercises can be attributed to specific factors. These exercises are designed to specifically target the hip flexor muscles, which are essential for hip mobility. Males often benefit significantly from the heightened emphasis on strengthening and stretching these particular muscle groups (Chaabene,

Behm, Negra, & Granacher, 2019; Hands, Larkin, Cantell, & Rose, 2016). Additionally, it may be assumed that consistent practice and personalized training provided for males, contribute to their ability to achieve substantial and remarkable increases in hip joint flexibility (Brusco, et al., 2018). This combination of targeted exercises and tailored instruction enhances their overall flexibility effectively.

Conversely, the Unilateral Exercise Group initially displayed a mean hip joint flexibility rating of "*good*" at 108.05. Following the intervention, this group exhibited a notable increase to an "*outstanding*" level of 136.21. This indicates that male participants were able to achieve very high levels of hip joint flexibility when performing exercises that focus on one side of the body at a time (Unilateral Exercises). This improvement suggests that the participants' hip joint flexibility reached a suggestively enhanced state as a direct result of engaging in these Unilateral Exercises (Polsgrove, Eggleston, & Lockyer, 2016). It can be construed that such result underscores the highly effective nature of these exercises in enhancing hip joint flexibility among the male participants.

The data further reveal a notably larger standard deviation in the Flexor Exercises Group, indicating a wider range of hip flexibility scores. This variance, however, is tempered by the small sample sizes within each category, which may limit the extent to which these findings can be generalized. Furthermore, the modest participant count in the Flexor Exercise Group raises the possibility that any significant changes in hip flexibility post-intervention might have gone undetected. The brevity and infrequency of the interventions also cast doubt on their effectiveness, suggesting that they were insufficient to bring about marked improvements in hip joint flexibility.

This finding resonates with the discoveries made by Moreside and McGill (2013), who noted that even though participants made significant strides in passive hip range of motion, there was no simultaneous improvement in hip range of motion during functional movements. This underscores the critical role of comprehensive and extended interventions in bringing about substantial changes in functional movement patterns. The notion finds reinforcement in the study conducted by Ehlers and Fanning (2019), which reported that participants who engaged in exercises with higher frequency and duration achieved more substantial improvements in hip joint flexibility.

Furthermore, Unilateral Exercises Group's results indicate that the intervention effectively enhanced the male participants' hip joint flexibility across all initial flexibility levels, as evidenced by the reduction in participants in the "*poor*" and "*fair*" categories and the increase in those in the "*Very Good*" to "*Outstanding*" categories. This shift implies that the Unilateral Exercises were believed to have cause the improvement of hip joint flexibility among the male participants. The data further reflects the success of the intervention in enhancing their hip joint mobility and range of motion.

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Additionally, this improvement can be attributed to the use of specific Unilateral Exercises such as Bulgarian split squat, Step-ups, and Single leg standing which addresses hip muscle imbalances. The increased range of motion may have contributed to the favorable outcomes observed in the Unilateral Exercises Group, as these exercises often involve extensive ranges of motion designed to promote joint flexibility and mobility. Sharma (2015) proposed that heightened range of motion or improved performance latitude in specific movements or patterns is indicative of enhanced joint and muscle function and flexibility.

Table 2 presents the frequency, percentage, and mean distribution of the female group's hip joint flexibility before and after the interventions, with the Flexor and Unilateral Exercises groups as the interventions.
The table shows that the overall mean for the Flexor Exercise Group's female participants before the intervention was 96.03 interpreted as *"fair"* which subsequently showed a mean increase from "*fair*" (96.03) to "*outstanding*" (140.76). Moreover, the data shows a decline in the percentage of participants labeled with "*fair*" flexibility, dropping from 35% to 0%, while the percentage of those categorized as having "*poor*" flexibility also decreased from 27.5% to 0%. These findings reveal a consistent pattern of increased performance among female participants in exercises targeting their flexor muscles, showcasing elevated levels of strength, flexibility, and proficiency that exceed anticipated benchmarks.

Table 2
Frequency, Percentage and Mean Distribution of the Female Participants' Hip Flexibility Before and After Interventions

Range	Interpretation	GROUP 1 Flexor Exercise				GROUP 2 Unilateral Exercises			
		Pretest		Post Test		Pretest		Post Test	
		F	%	F	%	F	%	F	%
47-86	Outstanding	3	7.5	38	95.0	2	5.0	35	87.5
87-98	Very Good	5	12.5	2	5.0	9	22.5	5	12.5
99-108	Good	7	17.5	0	0.0	14	35.0	0	0.0
109-122	Fair	14	35.0	0	0.0	11	27.5	0	0.0
123-167	Poor	11	27.5	0	0.0	4	10.0	0	0.0
Total		40	100	40	100	40	100	40	100
Mean		96.03		140.76		102.38		133.51	
Interpretation		Fair		Outstanding		Good		Outstanding	
SD		16.40		13.89		11.89		9.46	

This observation aligns with the subsequent studies, collectively indicating that females across various age groups and conditions consistently achieve substantial strength gains in flexor muscle-engaging exercises. Hanney's 2016 study, for instance, exposed pronounced Flexor to extensor imbalances in female recreational resistance training participants, signifying unique training effects, particularly in flexor muscle engagement. LeCheminant's 2014 research emphasized the superiority of resistance training over flexibility training for postpartum women, accentuating its role in fostering flexor muscle development. Furthermore, Gentil's 2015 study demonstrated that untrained young women experienced similar strength improvements in both upper and lower body flexor muscles through resistance training, affirming its overall effectiveness in enhancing muscle strength, especially in the context of Flexor Exercises.

Conversely, the female participants who engaged in Unilateral Exercises initially achieved a mean score of 102.38, which fell within the "*good*" range. However, following the intervention, their scores improved, reaching an "*outstanding*" level at 133.51. Furthermore, there is a decrease in the percentage of participants classified with "*good*" flexibility, declining from 35% to 0%, while the percentage of participants categorized as having "*fair*" flexibility also dropped from 27.5% to 0%. These results reveal that the participants achieved an improvement in these exercises, highlighting the possible effect of Unilateral Exercises.

This improvement likely reflects the specific benefits of Unilateral exercises, such as enhanced muscle balance, coordination, and Unilateral strength. These attributes are particularly valuable for overall functional fitness and injury prevention (O'Reilly, Kerksick, & Feutz, 2017; Botton et al., 2016; Razian et al., 2022). This outcome holds significance in understanding the impact of Unilateral exercises on the broader female population, both in the context of physical training and rehabilitation.

Engaging in Unilateral Exercises offers various physiological and psychological advantages for female participants. For instance, a study by Botton et al. (2016) demonstrated that Unilateral training results in a more substantial increase in Unilateral isometric strength compared to bilateral training, although both approaches improve muscle strength in untrained women. Moreover, regular exercise participation, which can include Unilateral exercises, has been associated with higher sensation-seeking levels among female university students, as indicated by Tekin, Tekin, & Çalışır in 2017. These findings collectively suggest that incorporating Unilateral Exercises can lead to significant enhancements in physical strength and psychological well-being among female participants.

The findings of the study provide interesting insights into the success of the different training interventions. Both the Flexor and Unilateral groups showed improvements in hip joint flexibility, indicating that each intervention method was successful to some degree.

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Furthermore, the concept of individual differences, as explored by Ørskov and group (2021), introduces a crucial aspect to these findings. This theory underscores the unique physiological and psychological makeup of each participant, which can lead to varied responses to the same training regimen. Such individual variability is a key factor in understanding the different degrees of improvement observed across participants.

Problem 2: Do the two groups significantly differ in their hip joint flexibility before and after the interventions?

Ho1: The participants' hip joint flexibility does not significantly differ before and after the interventions in both groups.

Table 3 presents the results of the t-test for paired samples for the male participants' hip joint flexibility before and after the interventions in the flexor and unilateral groups.

Table 3 Result of the Paired Samples T-Test of Difference in the Male Participants' Hip Joint Flexibility Before and After the Interventions

	Group 1 Flexor Exercise					Group 2 Unilateral Exercise				
	Pre Test	Post Test	t	p	d	Pre Test	Post Test	t	p	d
Hip Joint Flexibility	102.21	142.00	-10.41**	.000	-1.5	108.05	136.21	-9.94**	.000	-1.5

**significant at 0.01 level

The mean and standard deviation of the pretest and posttest values are reported, along with the t-statistic, p-value, and Cohen's d-effect size. As evident from the table, the Flexor Exercise Group's mean hip joint flexibility significantly increased from 102.21 to 142.00 ($t(43) = -10.41$, $p < .000$, Cohen's $d = -1.5$), indicating a large effect in terms of size. The observed improvements in hip joint flexibility among male participants in the Flexor Exercise Group indicate the effectiveness of the aforementioned intervention.

As a result, the null hypothesis is rejected. The decision is based on the observed differences in hip joint flexibility in the Flexor and comparison groups before and after interventions. The data strongly indicate that Flexor Exercises are particularly effective in improving hip flexibility. This result not only validates the Flexor intervention's effectiveness but also offers key insights for future strategies in physical training and rehabilitation aimed at enhancing joint flexibility.

In a related study, Tottori and team (2018) investigated the impact of a hip Flexor training program on fifteen boys, revealing that increased hip Flexor strength in males significantly enhanced sports performance. This improvement is thought to be linked to the potential increase in moments, likely achieved through a higher step frequency rather than an increase in step length during physical

activities. This aspect of the research further underscores the importance of hip Flexor strength and flexibility, not just for general health, but specifically in the context of athletic performance.

In the Unilateral Exercise Group, a significant increase in mean hip joint flexibility was observed, rising from 108.05 to 136.21. This change, reflected in the statistical values ($t(43) = -9.94$, $p < .000$, $d = -1.5$), indicates a large effect size. Such a marked improvement in the lateral hip joint flexibility of male participants strongly supports the effectiveness of the Unilateral intervention. Consequently, the hypothesis predicting no significant change can be rejected. These findings confirm that the participants' hip joint flexibility differed substantially before and after the interventions in both groups, thereby validating the efficacy of Unilateral Exercises in enhancing hip joint flexibility.

Complementing these findings, Razian and colleagues (2022) explored the effects of Unilateral training on thirty-nine females. Their research uncovered asymmetrical cross-education training adaptations, particularly noticeable in Unilateral training of the non-dominant leg. These adaptations extended to contralateral homologous and heterologous muscles, excluding the knee Flexors. The implications of this study are significant, presenting a novel approach or strategy for exercises aimed at addressing conditions related to the lower limbs and their associated muscles. This suggests that Unilateral training can have broad and varied impacts, not just on the trained limb but also on the untrained contralateral side, opening new avenues in physical therapy and training regimes.

Overall, there is a possibility that the stretching of the Flexor Exercise group helped them become more flexible. The repetitions of exercises may have also caused neural modifications in the muscle tissue that have increased flexibility. This discovery aligns with the research conducted by Nelson and the group (2020), advocating that consistent muscle stretching contributes to the enhancement of an individual's flexibility and mobility.

Table 4 Presents the paired sample t-test results for the female participants' hip joint flexibility before and after the interventions in both the Flexor and Unilateral Exercise Groups. The results show that there was a significant improvement in the hip joint flexibility of the female participants in the Flexor Exercise group ($t(40)= -11.86$, $p < .000$ Cohen's $d = -1.8$), while the Unilateral Exercise group showed as well a significant improvement ($t(40) = -10.707$, $p < .001$, Cohen's $d = -1.6$). The significant results for both the Flexor and Unilateral Exercise Groups at the .01 level of significance demonstrate that the improvements in hip joint flexibility are not merely due to chance. The Cohen's d effect sizes of -1.8 for the Flexor group and -1.6 for the Unilateral group, categorized as exceptionally large and medium respectively, indicate a substantial enhancement in hip flexibility. Given these significant results, the hypothesis positing no improvement in hip joint flexibility due to these exercises can be rejected for both groups.

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Table 4 Result of the Paired Sample T-Test of Difference in the Female Participants' Hip Joint Flexibility Before and After the Interventions

	Group 1 Flexor Exercise					Group 2 Unilateral Exercise				
	Pre Test	Post Test	t	p	d	Pre Test	Post Test	t	p	d
Hip Joint Flexibility	96.03	140.76	-11.86**	.000	-1.8	102.38	133.51	-10.70**	.000	-1.6

In essence, both Flexor and Unilateral Exercises have proven efficacy in enhancing hip joint flexibility. The efficacy lies in the intricate interplay between the nervous system and muscles (Teichmann & colleagues, 2021). During flexor stretches, the activation of muscle fibers by motor neurons generates force, effectively loosening tight and weak hip flexors.

Moreover, Unilateral Exercises contribute to addressing imbalances in hip muscle and joint range. Optimal muscle function is achieved when muscles operate within their ideal length-tension relationship (Sharma, et al., 2021). Through these exercises, this relationship is optimized, further aiding in the improvement of hip flexibility.

Based on previous research (Aslan et al., 2018), hip Flexor stretching contributed a substantial enhancement in hip extension ROM, proving more effective than dynamic stretches. Additionally, research (Botton et al., 2016) indicates that the total forces generated by each limb during Unilateral conditions are higher than those produced during bilateral conditions. This underscores the potency of Unilateral training in fostering specific strength and flexibility gains on the Unilateral level.

Through diligent observation over the course of the intervention period, discernible advancements in exercise execution were noted among participants. Initially, varying levels of proficiency were evident, ranging from limited execution to proficient and excellent performances. As the intervention progressed, a majority demonstrated a commendable refinement in their execution, displaying heightened confidence. This collective improvement significantly contributed to their enhancement of hip joint flexibility.

Problem 3 Do the increments of the two groups of participants hip joint flexibility significantly differ?
Ho2. The increments of the two groups of participants' hip joint flexibility do not significantly differ.

Table 5 shows the results of an independent sample t-test conducted to compare the hip joint flexibility increments between the male Flexor and Unilateral Exercise Groups. The Flexor Exercise group's mean hip joint flexibility increment was 39.78, while the mean of the Unilateral

Exercise group was 28.16. The t-test revealed a significant result with W = 1163.50, p = 0.03, and an effect size of 0.259. The result suggests that there is a statistically significant difference between the two groups' hip joint flexibility increments. However, the effect size is only small. Therefore, the hypothesis is rejected. While both Flexor and Unilateral Exercises can be effective for improving hip joint flexibility in males, flexor is slightly more effective. This is due to the wider, equal range of muscles and activation during Flexor exercises compared to Unilateral exercises (Sasak et. al., 2019). Additionally, the specific Flexor Exercises may have contributed to the effectiveness of the intervention in improving hip joint flexibility across all levels of initial flexibility (Konrad et. al., 2021).

Table 5. Result of the Test of Difference (Mann-Whitney U Test) in the Two Groups of Male Participants' Hip Joint Flexibility Increments

Hip Joint Flexibility	Flexor Exercises	Unilateral Flexors	W	p	Effect size
Mean Increment	39.78	28.16	1163.500*	0.039	0.259
SD	25.05	18.56			

**significant at 0.05 level

The Flexor group's mean hip joint flexibility increment was 39.78, while the mean of the Unilateral group was 28.16. The t-test revealed a relatively small difference result with W = 1163.000*, p = 0.039, and an effect size of 0.259. The result suggests that there is a statistically significant difference between the two groups' hip joint flexibility increments. However, the effect size is only small. Therefore, the hypothesis is rejected. While both Flexor and Unilateral Exercises can be effective for improving hip joint flexibility in males, Flexor Exercises is slightly more effective. This is due to the wider, equal range of muscles and activation during Flexor Exercises compared to Unilateral exercises (Sasak et. al., 2019). Additionally, the specific Flexor Exercises may have contributed to the effectiveness of the intervention in improving hip joint flexibility across all levels of initial flexibility (Konrad et. al., 2021).

Table 6 presents the results of the independent sample t-test conducted to compare the increments in hip joint flexibility between the female flexor and unilateral groups.

Table 6. Result of the Test of Difference in the Two Groups of Female Participants' Hip Joint Flexibility Increments

Hip Joint Flexibility	Flexor Exercises	Unilateral Flexors	t	p	d
Mean Increment	44.73	31.12	2.858	.000	0.639
SD	23.85	18.38			

**significant at 0.05 level

The mean increment for the Flexor Exercise group is 44.73, which implies greater change, while that of the Unilateral Exercise group is 31.12. The t=2.858, is significant at the .05 level, indicating that the null hypothesis can be rejected. Cohen's d value is 0.639, which indicates a moderate effect size. Such a moderate effect size suggests that there is a practical significance of the intervention (Cohen, 2013). This implies that while both exercises contribute to enhancing hip joint flexibility, the utilization of Flexor Exercises may be more advantageous than Unilateral Exercises, as indicated by the study's outcomes. Hip flexor stretching emerge as pivotal component in interventions aimed at enhancing ROM (Preece et. al.,2021). This is substantiated by the theory of neuromuscular activation, positing that muscles optimize performance through stimulation.

Potential contributors to these results include the specific stretches employed in the Flexor intervention, which entail simultaneous and balanced muscle training aimed at enhancing both strength and flexibility. Additionally, the Flexor intervention specifically focused on improving hip joint flexibility (Lobel, 2016). Furthermore, the Unilateral intervention also targeted the hip joint through the incorporation of single-limb stretches, contributing to the observed improvement in hip joint flexibility.

Furthermore, there was a significant difference in the results of male and female groups, with the Flexor Exercise group exhibiting greater performance. One influential factor considered is the effectiveness of hip Flexor stretching in increasing muscle length and hip extension, as demonstrated in previous research (Watt et al., 2011).

CONCLUSION

The study effectively met its objective of assessing the impact of Flexor and Unilateral Exercises on enhancing hip joint flexibility. Key to this investigation was the implementation of these exercises within a classroom setting, presenting a safe alternative to more high-risk activities. Significantly, the study's findings indicate that these exercises not only improve hip joint flexibility but also contribute to an overall enhancement in performance. The core of this success lies in the proven effectiveness of the Flexor and Unilateral exercises. Their strategic use was instrumental in achieving the stated goal of the study, marking an essential advancement in the understanding of physical exercise's role in health and fitness education.

In addition, the study assumed that both of its interventions—Flexor and Unilateral—greatly enhance participants' hip joint flexibility or range of motion. This assumption was confirmed and deemed accurate as revealed in the results of this study. Also, the utilization of quasi-experimental research design is of paramount importance since it tested how well it achieved the study’s thrust.

Nevertheless, the utilization of theories played a crucial role in influencing the effectiveness of the interventions by incorporating the theory of neuromuscular and muscular activation in Flexor Exercises and the theory of muscle length and flexibility in Unilateral Exercises, a focused and

strategic approach was achieved. This purposeful adherence to established theories substantially contributed to the precision and success of the interventions, ultimately leading to notable improvements in hip joint flexibility among the participants.

Moreover, this study's success in enhancing hip joint flexibility through Flexor and Unilateral Exercises offers invaluable insights for dance educators. By integrating these exercises, tailored to the theories of neuromuscular and muscular activation and muscle length and flexibility, dance instructors can effectively improve their students' flexibility and range of motion within the safe confines of the classroom. This approach not only aligns with the physical demands of dance but also contributes to injury prevention and overall performance enhancement, providing a practical and theory-based model for dance education.

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