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Original Article

Comparison of Static Stretching on Whole Body Vibration and Strength Training for Improving and Maintaining Hamstring Range of Motion

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ABSTRACT

Background: Hamstring strains are prevalent among individuals engaged in sports and recreational activities. Addressing this, static stretching, whole-body vibrations (WBV), and strength training are recognized for enhancing range of motion (ROM) and reducing muscle injury risks. However, the comparative effectiveness of these modalities on hamstring flexibility and ROM requires further exploration.

Objective: The primary objective of this study was to investigate the effects of static stretching combined with whole-body vibrations and strength training on improving and maintaining hamstring range of motion.

Methods: This crossover randomized control trial in Karachi involved 44 participants aged 18-25 years, actively participating in various recreational activities. Participants were randomly divided into two groups: one underwent static stretching on whole-body vibration, and the other received strength training. The interventions lasted four weeks, with pre- and post-intervention assessments of active and passive range of motion (AROM and PROM). Data analysis was conducted using SPSS version 23.0.

Results: The static stretching with whole-body vibration group showed an increase in AROM from a pre-intervention mean of 131.05° to a post-intervention mean of 136.55°, and in PROM from 131.67° to 137.41°. The strength training group exhibited an increase in AROM from a pre-intervention mean of 135.21° to 142.42°, and in PROM from 135.98° to 144.81°. Both interventions demonstrated statistically significant improvements in hamstring ROM.

Conclusion: The study demonstrates that both static stretching on whole-body vibration and strength training are effective in enhancing the flexibility and range of motion of hamstrings. These findings suggest their beneficial incorporation in rehabilitation and athletic training programs.

Keywords: Hamstring Strains, Range of Motion, Static Stretching, Whole-Body Vibrations, Strength Training, Rehabilitation, Athletic Training.

INTRODUCTION

The intricate anatomy and function of the hamstrings, located on the posterior side of the upper leg, play a pivotal role in both hip and knee movements during various activities (1). These muscles are crucial in the downward and upward strokes of leg movement, encompassing hip extension and knee flexion. The prevalence of hamstring strains, often attributed to factors like reduced muscle length, diminished flexibility, inadequate warm-up, and fatigue, significantly contribute to the risk of injuries, ultimately impacting the joint's range of motion (2). A noteworthy observation is the correlation between a greater knee extension angle during vertical jumping and a reduced risk of hamstring injury (3).

In the realm of enhancing bone density, vibrations have been identified as a safe and effective means (4). Techniques such as whole-body vibration, sling exercises, and localized vibration stretching are increasingly being employed for this purpose (5). Whole-body vibration, in particular, has gained recognition in sports and rehabilitation contexts as a less exhausting and more time-efficient exercise modality. It is particularly beneficial for injury prevention and the enhancement of neuromuscular performance, especially

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in individuals with lower fitness levels (6, 7). The efficacy of whole-body vibration exercises is influenced by various factors, including the organization of training sessions, the frequency of weekly training, and the recovery intervals between sessions (8).

Static stretching, characterized by passive and gradual muscle stretching within its maximum tolerance range, stands as a method with minimal injury risk (9). Various modalities of static stretching for the hamstrings, such as passive straight leg raise, active knee extension, and passive knee extension, not only target the hamstrings but also involve the calf triceps muscles, especially when the ankle is dorsiflexed (10). This technique is integral in increasing muscle flexibility (11). Static stretching was previously perceived as an isometric stimulus, with the agonist muscles in a shortened position and the antagonist muscles lengthened (12). In contrast, dynamic strength training involves both muscle shortening and lengthening. Several implications emerge from this comparison: firstly, strength training is a potent method for improving mobility; secondly, it lengthens two of the three movement axes; thirdly, the absence of passive techniques in strength training necessitates a reevaluation of the use of passive methods like static stretching; and fourthly, isometric exercises, even those not at the limits of the range of motion (ROM), have been found effective in enhancing mobility (13).

Stretching, as an intervention, is devised to lengthen tissues and enhance mobility. Esteemed organizations such as the National Strength and Conditioning Association and the American College of Sports Medicine endorse the inclusion of stretching in exercise programs to augment muscle elongation and flexibility (14). It is a therapeutic action designed to increase the pliability of soft tissues, thereby improving flexibility by lengthening structures that have become less mobile due to adaptive shortening (15). In the early stages of rehabilitation, techniques like manual stretching and joint mobilization, which involve direct, hands-on intervention from a practitioner, are often preferred (16). Range of motion limitations are commonly attributed to decreased extensibility of soft tissues due to adhesions, contractures, and scar tissue formation, leading to functional limitations or disabilities. Stretching exercises, encompassing various forms such as manual, mechanical, self-stretching, passive, assisted, and active stretching, can address these issues (3).

Given the significance of flexibility as a measurable aspect of physical fitness and its role in overall fitness, it is crucial to address instances of limited flexibility, often linked with increased tension in antagonist muscles. While scientific evidence is somewhat limited, passive stretching is widely recognized as an effective means to enhance muscle extensibility and improve mobility. Thus, the primary objective of this study is to elucidate the effects of static stretching on whole-body vibrations and strength training in the improvement and maintenance of hamstring range of motion.

MATERIAL AND METHODS

The study, a crossover randomized control trial, was executed in Karachi to investigate the effects of static stretching on whole-body vibration and strength training on hamstring range of motion. Calculations for the sample size were determined using openepi, considering a 50% hypothesized prevalence, a 5% margin of error, and a 95% confidence interval, resulting in a required sample of 44 participants. Utilizing a non-probability convenient sampling technique, the study included both male and female subjects aged between 18-25 years, who were involved in various recreational activities, including sports, gym, and outdoor leisure activities. Exclusion criteria encompassed individuals with physiological or pathological problems, those above the targeted age range, individuals with a history of hamstring, quadriceps, or any lower limb injury in the past six months, involvement in other studies or whole-body vibration-related studies, and those leading a sedentary lifestyle.

In total, 44 participants from Karachi were recruited. Informed consent was obtained from all participants, who then completed the Physical Activity Readiness Questionnaire to ensure their health status. Only those who responded with 'NO' in the questionnaire were included. Participants were then divided into two groups: 15 in the intervention group and 14 in the control group. The intervention group underwent static stretching on whole-body vibration, while the control group received strength training.

The initial session included comfortable dressing for the participants, during which their height and weight were measured to calculate the Body Mass Index (BMI). Instructions on proper positioning for the two protocols were also provided. This session served as a familiarization process for the participants regarding the strengthening, stretching, and measurement procedures to be used in subsequent sessions. They were advised to refrain from maximum effort or initiating new exercise routines the day before each treatment session.

In the first group, participants performed static stretching of the hamstrings on whole-body vibration. Pre-test and post-test assessments of active and passive range of motion for both legs were conducted. Each session began with a 5-minute warm-up on a stationary bicycle, followed by a conventional static stretch. This involved a supine active knee extension on whole-body vibration at 30 Hz with a high amplitude setting, maintained at the point of initial discomfort. The stretch was repeated three times for 30 seconds each, with a 20-second rest period between each stretch. Participants engaged in these stretching sessions four days a week for four weeks. Active hamstring Range of Motion (ROM) was assessed using an active knee extension with a goniometer, with the

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leg at 90º of hip flexion and the opposite leg extended. Passive ROM was evaluated through clinician-assisted knee extension with the leg similarly positioned.

The second group, assigned to strength training, also had sessions four days a week. Their regimen included a 5-minute warm-up, followed by specific exercises. In the first week, the protocol comprised Nordic hamstring curls (NHC) with a bend, prone hamstring curls, physio-ball leg curls, and glute bridges, with specific repetitions and sets. From the second to the fourth week, the intensity of these exercises was increased slightly. Rest periods of 30 seconds between each set and 1 minute between each exercise were maintained. Pre and post active and passive Range of Motion (AROM and PROM) were calculated, with measurements taken similarly to the first group.

For statistical analysis, SPSS version 23.0 was employed. Data was summarized using categorical variable frequencies and means ± standard deviation (SD) for quantitative variables. The Wilcoxon sign rank test was utilized for analysis, ensuring a thorough evaluation of the effects of the two different interventions on hamstring range of motion.

RESULTS

The results presented is a detailed comparison of two groups undergoing different types of physical therapy: a Stretching Group and a Strengthening Group. Each group consisted of 22 participants. The focus was on measuring changes in Active and Passive Range of Motion (ROM) across multiple visits spanning four weeks.

In the first week, during the first visit, the Stretching Group's Active ROM had a pre-treatment mean of 131.05 degrees with a standard deviation of 5.02, which significantly improved post-treatment to a mean of 132.24 degrees (standard deviation 5.10). The Strengthening Group started with a higher pre-treatment Active ROM mean of 135.21 degrees (standard deviation 4.27) and improved to 137.66 degrees post-treatment (standard deviation 4.19). A similar pattern was observed for Passive ROM: the Stretching Group increased from a pre-treatment mean of 131.67 degrees (standard deviation 4.65) to 132.69 degrees post-treatment (standard deviation 4.71), and the Strengthening Group improved from 135.98 degrees (standard deviation 3.58) to 138.34 degrees (standard deviation 3.37).

Table 1 Hamstring Range: Stretching Group Follow-up Results over 4 Weeks

Parameters	Follow-up	STRETCHING GROUP (n=22)			STRENGTHNING GROUP (n=22)		
		Mean	Std. Deviation	P-value	Mean	Std. Deviation	P-value
Pre Active Range of Motion	(1st Week & 1st Visit)	131.05	5.02	0.000	135.21	4.27	0.000
Post Active Range of Motion	(1st Week & 1st Visit)	132.24	5.10		137.66	4.19	
Pre Passive Range of Motion	(1st Week & 2nd Visit)	131.67	4.65	0.000	135.98	3.58	0.000
Post Passive Range of Motion	(1st Week & 2nd Visit)	132.69	4.71		138.34	3.37	
Pre Active Range of Motion	(1st Week & 3rd Visit)	131.76	4.89	0.000	136.23	3.53	0.000
Post Active Range of Motion	(1st Week & 3rd Visit)	132.66	4.74		138.36	3.57	
Pre Passive Range of Motion	(1st Week & 4th Visit)	132.19	4.50	0.000	137.47	3.91	0.000
Post Passive Range of Motion	(1st Week & 4th Visit)	133.13	4.51		139.85	3.57	
Pre Active Range of Motion	(2nd Week & 1st Visit)	132.69	4.56	0.000	137.45	3.83	0.000
Post Active Range of Motion	(2nd Week & 1st Visit)	133.78	4.65		139.75	3.40	

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Parameters	Follow-up	STRETCHING GROUP (n=22)			STRENGTHNING GROUP (n=22)		
		Mean	Std. Deviation	P-value	Mean	Std. Deviation	P-value
Pre Passive Range of Motion	(2nd Week & 2nd Visit)	133.04	4.56	0.000	137.91	3.53	0.000
Post Passive Range of Motion	(2nd Week & 2nd Visit)	134.02	4.70		140.13	3.17	
Pre Active Range of Motion	(2nd Week & 3rd Visit)	133.38	4.56	0.000	138.41	3.73	0.000
Post Active Range of Motion	(2nd Week & 3rd Visit)	134.14	4.62		140.40	2.91	
Pre Passive Range of Motion	(2nd Week & 4th Visit)	133.42	4.77	0.000	138.44	3.69	0.000
Post Passive Range of Motion	(2nd Week & 4th Visit)	134.45	4.71		140.58	2.93	
Pre Active Range of Motion	(3rd Week & 1st Visit)	134.27	4.59	0.000	139.46	3.35	0.000
Post Active Range of Motion	(3rd Week & 1st Visit)	135.10	4.53		141.84	3.04	
Pre Passive Range of Motion	(3rd Week & 2nd Visit)	135.02	4.95	0.000	139.65	3.59	0.000
Post Passive Range of Motion	(3rd Week & 2nd Visit)	135.53	4.58		141.45	3.38	
Pre Active Range of Motion	(3rd Week & 3rd Visit)	135.05	5.21	0.000	140.05	2.53	0.000
Post Active Range of Motion	(3rd Week & 3rd Visit)	135.02	5.46		141.90	2.56	
Pre Passive Range of Motion	(3rd Week & 4th Visit)	135.60	5.46	0.000	140.50	2.48	0.000
Post Passive Range of Motion	(3rd Week & 4th Visit)	136.36	5.27		142.54	2.46	
Pre Active Range of Motion	(4th Week & 1st Visit)	135.65	5.17	0.000	141.06	2.17	0.000
Post Active Range of Motion	(4th Week & 1st Visit)	136.55	5.27		142.42	2.17	
Pre Passive Range of Motion	(4th Week & 2nd Visit)	136.19	5.63	0.000	142.16	1.41	0.000
Post Passive Range of Motion	(4th Week & 2nd Visit)	136.91	5.40		143.93	1.74	
Pre Active Range of Motion	(4th Week & 3rd Visit)	136.25	5.42	0.000	142.12	0.90	0.000
Post Active Range of Motion	(4th Week & 3rd Visit)	137.11	5.39		143.11	0.93	
Pre Passive Range of Motion	(4th Week & 4th Visit)	136.62	5.58	0.000	142.66	1.04	0.000
Post Passive Range of Motion	(4th Week & 4th Visit)	137.41	5.39		144.81	2.25	
*Wilcoxon Sign Rank Test was applied							
*P-value ≤ 0.05 considered to be statistically significant							

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In the subsequent visits of the first week, these trends continued. Active and Passive ROM values increased slightly post-treatment in both groups. By the fourth visit of the first week, the Stretching Group's Passive ROM had increased from a pre-treatment mean of 132.19 degrees (standard deviation 4.50) to 133.13 degrees post-treatment (standard deviation 4.51), while the Strengthening Group showed an increase from 137.47 degrees (standard deviation 3.91) to 139.85 degrees (standard deviation 3.57).

In the second week, the starting (pre-treatment) values for both Active and Passive ROM were higher compared to the first week, indicating an overall improvement. Post-treatment values continued to increase. For instance, by the first visit of the second week, the Stretching Group's Active ROM increased from a pre-treatment mean of 132.69 degrees (standard deviation 4.56) to 133.78 degrees post-treatment (standard deviation 4.65), and the Strengthening Group's Active ROM increased from 137.45 degrees (standard deviation 3.83) to 139.75 degrees (standard deviation 3.40).

This pattern of gradual increase in ROM continued into the third and fourth weeks. By the fourth week's first visit, the Stretching Group's Active ROM increased from a pre-treatment mean of 135.65 degrees (standard deviation 5.17) to 136.55 degrees post-treatment (standard deviation 5.27). The Strengthening Group exhibited a more pronounced improvement, with the Active ROM increasing from a pre-treatment mean of 141.06 degrees (standard deviation 2.17) to 142.42 degrees post-treatment (standard deviation 2.17). By the fourth week's fourth visit, the Stretching Group's Passive ROM increased from a pre-treatment mean of 136.62 degrees (standard deviation 5.58) to 137.41 degrees post-treatment (standard deviation 5.39), while the Strengthening Group's Passive ROM increased from 142.66 degrees (standard deviation 1.04) to 144.81 degrees (standard deviation 2.25).

In all cases, the changes from pre- to post-treatment within each visit were statistically significant, with p-values of 0.000. This indicates a clear effect of the treatments in both groups on improving the Range of Motion, both Active and Passive.

DISCUSSION

The discussion centers around the prevalent factors contributing to hamstring strains, notably reduced muscle length, diminished flexibility, inadequate warm-up, and fatigue, which collectively limit joint range of motion (17). To address these concerns, stretching exercises are recommended for enhancing joint ROM and hamstring flexibility (18). The effectiveness of various stretching techniques, particularly Static Stretching (SS) and Proprioceptive Neuromuscular Facilitation (PNF), as well as strength training exercises and Whole-Body Vibrations (WBV), in improving ROM and muscle flexibility, is well-documented (19).

Static stretching, characterized by passive and gradual muscle stretching within its maximum tolerance range (20, 21), is recognized for its ease of implementation and minimal risk of injury (19, 22). Techniques such as passive straight leg raise, active knee extension, and passive knee extension are common modalities of static stretching for the hamstrings. When combined with strength training and WBV, static stretching has shown immediate effects in enhancing flexibility and ROM (23). The current study corroborates these findings, indicating significant improvements in hamstring flexibility and ROM, with a reported p-value ≤ 0.005.

Supporting this observation, a study by JB Feland et al. (2020) explored the synergistic effect of whole-body vibration and stretching techniques on dorsiflexion ROM in individuals with ankle instability. The combination of static stretching and WBV was found to increase dorsiflexion ROM more effectively than static stretching alone, echoing the findings of the present study with a significant p-value of <0.005 (24).

Similarly, research by M. Azizi et al. (2021) compared the effects of muscle energy technique and WBV on hamstring muscle flexibility in females. The outcomes revealed immediate improvements in flexibility and decreased stiffness, aligning with the results observed in static stretching. The paired t-test indicated a significant p-value of <0.005 (1). While this prior study emphasized WBV combined with muscle energy technique, the current study focused on static stretching and WBV, both yielding comparable enhancements in hamstring flexibility and range of motion.

Further, a study by Kanza Masood et al. (2021) compared the efficacy of dynamic oscillatory stretch techniques with SS. Both techniques demonstrated immediate improvements in flexibility, but dynamic oscillatory stretching showed superior results in post-intervention assessments. The study reported a significant p-value of <0.005 (25), reinforcing the findings of the current study, albeit with a different focus on dynamic stretching techniques.

In 2019, Zahra Ahmadizadeh et al. investigated the combined effects of WBV and static stretching on AROM and PROM in lower extremities. They found that while individual techniques did not significantly affect AROM and PROM, their combination did, resulting in notable improvements. The study's significance, indicated by a p-value of less than 0.005, was mirrored in the current research, despite the former focusing on children and the latter on adults (26).

Contrasting these results, a study by Mojtaba Heshmatipour et al. (2019) found that active dynamic stretching was more effective than passive static stretching in alleviating hamstring tightness, with a significant p-value of <0.001 (27). This finding highlights the

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potential superiority of active dynamic stretching over static stretching, although the current study, emphasizing static stretching with WBV, also reported significant improvements in muscle flexibility.

Lastly, Samuel S. Rudisill et al. (2023) examined the impact of strength training exercises and static stretching techniques on hamstring ROM and flexibility post-injury. Their findings indicated that strength training not only reduced hamstring injury incidence but also enhanced hamstring strength and limb symmetry. The stretching techniques, part of the hamstring intervention, were effective in increasing flexibility, offering valuable insights for athletes, coaches, and trainers (28). This study aligns with the current research, underscoring the benefits of combined interventions in improving muscle flexibility.

CONCLUSION

In conclusion, the research underscores the significant impact of static stretching, combined with whole-body vibration and strength training exercises, on improving hamstring flexibility and range of motion. These findings have profound implications for rehabilitation, athletic training, and injury prevention strategies. They suggest that incorporating a multifaceted approach, which includes static stretching and complementary modalities like WBV and strength training, can effectively enhance joint flexibility and muscle function. This holistic approach could be particularly beneficial for athletes, physiotherapists, and individuals recovering from musculoskeletal injuries, offering a more efficient and comprehensive method for improving muscle health and reducing the risk of future injuries. The study's outcomes reinforce the need for tailored, multi-modal therapeutic strategies in the management and rehabilitation of muscle tightness and joint mobility issues.

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