**Exercise- and Muscle-Specific Adaptations in Hamstring Muscle and Aponeurosis Thickness**

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## Summary

Twenty-seven participants performed three resistance training sessions targeting the hamstrings using knee-based, hip-based, and mixed exercises. Muscle and aponeurosis thickness were assessed across the thigh length via ultrasound at multiple time points. Significant muscle- and exercise-specific adaptations were found, with the semitendinosus (ST) showing greater changes near the knee and the biceps femoris (BF) demonstrating distinct aponeurosis adaptations during specific exercises. These results highlight the importance of tailored exercise selection to target hamstrings muscles.

## Introduction

Resistance exercises induce localized muscle swelling, reflecting fluid shifts due to metabolic demands [1]. Hamstring exercises, categorized as knee-based, hip-based, or mixed, show inconsistent activation patterns across studies [2]. This study examines inter- and intra-muscular differences in hamstring swelling to identify differences following various exercises in hamstrings.

## Methods

Twenty-seven participants performed three hamstrings exercises in three training sessions: prone lying curls (knee-based), stiff leg deadlift (hip-based) and hamstrings bridge (mix-exercise). A randomized, crossover, and counterbalanced design was used with the participants performing 4 sets of 12 repetitions until concentric muscular failure. The muscle (MT) and superficial and deep aponeurosis thickness of BF, ST, and semimembranosus (SM) were obtained using ultrasound at baseline, immediately after, 5, 10, 15 and 30 minutes after exercise at five measurement sites along the length of each muscle. A computational image segmentation approach was used to analyze ultrasound images, which generated approximately ~300 data points per participant. The change in tissue thickness over time was compared with the baseline values. A three-way statistical parametric mapping analysis was used to assess the influence of muscle, exercise, and time on the changes in muscle and aponeurosis thickness.

## Results and Discussion

The statistical analysis indicated that ST exhibited greater changes in MT compared with the other muscles, particularly near the knee joint. Furthermore, the BF demonstrated significant differences in MT compared with SM across various exercises. Similarly, ST showed greater changes in superficial aponeurosis thickness after hamstring curls and stiff-leg deadlifts, whereas the BF exhibited greater changes after the hamstring bridge. In contrast, the BF displayed more pronounced changes in deep aponeurosis thickness compared with ST. Interestingly, localized variations were noted, with some regions of the muscles showing an increase in aponeurosis thickness, whereas others displayed a decrease, highlighting the heterogeneous response of the hamstring muscles to different exercises. Overall, muscle- and region-specific adaptations were observed in the hamstring muscles across different exercises. These findings may be explained by intra- and inter-muscular variations in architecture and activation patterns [3].

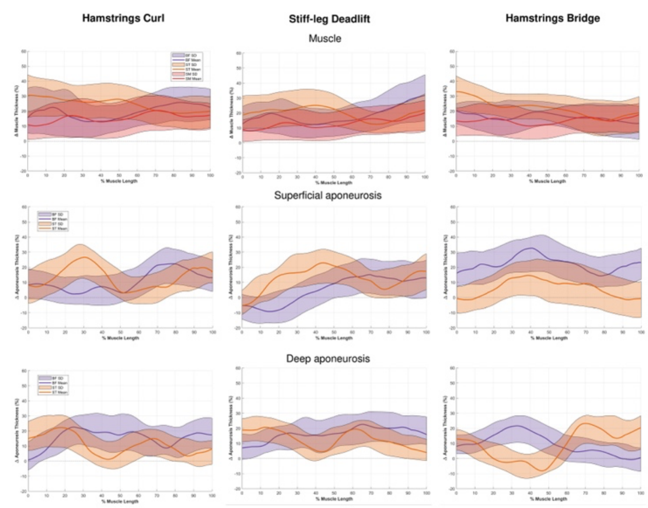


**Figure 1**: Changes in muscle and aponeurosis thickness (% relative to baseline) across the hamstrings for the curl, stiff-leg deadlift, and hamstrings bridge exercises. Panels depict muscle thickness (top row), superficial aponeurosis thickness (middle row), and deep aponeurosis thickness (bottom row) along the length of BF, ST, and SM. Thick line represent mean and shaded areas standard deviation.

## Conclusions

This study demonstrates that hamstring muscles exhibit distinct, exercise-specific adaptations in muscle and aponeurosis thickness, with notable variability across regions and time points. These findings provide valuable insights for optimizing training and rehabilitation strategies to enhance performance and prevent injuries.

## References

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