Contrasting Effects of Acute and Chronic Loading on Muscle Architecture: Evidence from Sumo Wrestlers

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Summary

While acute whole body loading decreases muscle fascicle length, sumo wrestlers (SUMO) and high BMI males under chronic heavy loading conditions show contradictory adaptations. This study compared muscle architecture between SUMO and two height-matched control groups: one with high BMI (>30) and one with normal BMI (<25) groups. Results demonstrated that SUMO and the high BMI group had significantly longer muscle fascicles and greater muscle thickness in both medial gastrocnemius and vastus lateralis compared to the low BMI group. These architectural characteristics differ from typical acute load-dependent muscle responses, suggesting distinct chronic load-dependent adaptations.

Introduction

In competitive sports, morphological characteristics such as muscle-tendon lengths significantly influence athletic performance, with distinct adaptations observed across different sports. These characteristics are influenced by both acquired adaptations through specific training and environmental factors, as well as inherent genetic factors, highlighting the complexity of human musculoskeletal plasticity. Previous research has demonstrated that muscle length immediately increases with unloading [1] and decreases with loading in controlled conditions [2]. However, sumo wrestlers (SUMO), who experience long-term weight-bearing conditions exceeding 100kg, exhibit significantly longer muscle lengths [3], which contradicts these established findings on the acute load-dependent muscle responses.

Therefore, this study aims to elucidate whether the longer muscle lengths observed in SUMO represent a sport-specific characteristics or load-dependent adaptation by comparing muscle architectural properties between SUMO and controls.

Methods

Subjects: Twenty-two male SUMO, twenty-two male controls with BMI over 30 (**$CTRL_{Heavy}$**) and twenty-two male controls with BMI of less than 25 (**$CTRL_{Light}$**), all with matching heights, participated in this study.

Protocol: Subjects were measured in a standing position. Muscle architecture was assessed using two B-mode ultrasonography (Prosound α10, Hitachi Ltd., Japan) with two 6-cm linear array probes (13 MHz). Muscle fascicle length of medial gastrocnemius (MG) and vastus lateralis (VL) were measured from ultrasound images, using Image J software (version 1.45s, NIH, USA).

Statistics: Values are presented as means ± standard deviations. A one-way analysis of variance was used to compare parameters between groups. When significant main effects were observed, Tukey post hoc tests were performed. Statistical significance was set at $p < 0.05$.

Results

As shown in Table 1, BMI and lean body mass index (LBMI) were higher in SUMO compared with both control groups. The muscle architecture measurements (Figure 1) revealed that both fascicle lengths and thickness were significantly greater in SUMO compared with control groups. The MG pennation angles were greater in both SUMO and $CTRL_{Heavy}$ than in $CTRL_{Light}$; however, SUMO exhibited smaller pennation angles than $CTRL_{Heavy}$. No significant differences were observed in VL pennation angles among groups.

Table 1: Physical characteristics of each group.

	SUMO	Heavy	Light
Height (m)	1.77 ± 0.06	1.76 ± 0.06	1.74 ± 0.07
Body mass (kg)	119.4 ± 15.7	110.5 ± 12.9	64.6 ± 10.1
BMI	38.2 ± 3.3	35.7 ± 3.1	21.5 ± 3.0
LBMI	28.1 ± 1.9	24.7 ± 1.9	17.6 ± 1.7
Fat(%)	26.2 ± 3.4	30.7 ± 5.1	17.4 ± 4.3

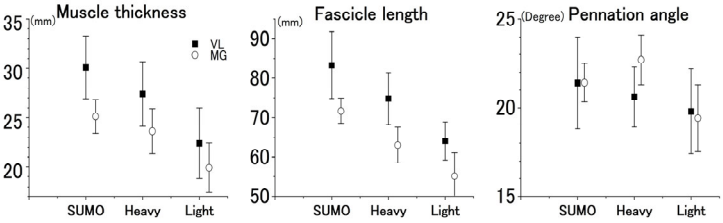

Figure 1. Muscle architectures of each group.

Discussion

This study demonstrated the contrasting effects between acute and chronic load-dependent muscle characteristics. While acute loading decreases muscle length, both SUMO and individuals with high BMI under chronic heavy loading showed longer muscle fascicles. Additionally, the differences between SUMO and $CTRL_{Heavy}$ suggest sport-specific adaptation. The characteristics of SUMO's unique quick movements without bouncing, such as "SURIASHI (sliding foot movements)", may promote adaptation to longer muscle fascicles and less enlarged pennation angles, which facilitate a greater range of motion.

References

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