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**EXTENDED  
ABSTRACT**

# Differences in Range of Motion on Gastrocnemius Hypertrophy Among Untrained Males

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## I. INTRODUCTION

While muscle hypertrophy has been extensively studied, the gastrocnemius remains underexplored, particularly in the context of range of motion (ROM) in resistance training. Recent evidence indicates that training at longer muscle lengths may lead to superior hypertrophic adaptations; however, the majority of existing research has focused on larger muscle groups such as the quadriceps or biceps [1][2]. This study examines the effects of full, initial, and final ROM on gastrocnemius hypertrophy and strength development in untrained males. By employing field-practical assessment tools such as circumference measurements and submaximal one-repetition maximum (1RM) testing, this research aims to address notable gaps in the literature related to muscle-specific adaptations, training adherence, and the practical application of ROM-specific protocols in real-world settings [3][4].

## II. METHODS

A randomized pretest-post-test experimental design was employed involving thirty healthy, untrained males aged 18–25 years from local gyms. Participants had no structured resistance training experience within the previous 12 months and were classified as physically inactive using the International Physical Activity Questionnaire (IPAQ). Participants were randomly assigned to one of three intervention groups: Full Range of Motion (FULLROM), Initial Range of Motion (INITIALROM), or Final Range of Motion (FINALROM). The intervention consisted of an eight-week supervised resistance training program using the seated calf raise exercise, performed three times per week. Each session comprised three sets of 10–12 repetitions at a load between 65–75% of estimated one-repetition maximum (1RM), with rest intervals of 2–3 minutes between sets. Range of motion was standardized using a goniometer: FULLROM (–25° dorsiflexion to +25° plantarflexion), INITIALROM (–25° to 0°), and FINALROM (0° to +25°), with all sessions monitored for adherence and technique. Gastrocnemius muscle hypertrophy was assessed pre- and post-intervention via circumference measurements at the widest part of the muscle using a non-elastic measuring tape, following ISAK anthropometric standards. Muscular strength was evaluated using a submaximal indirect 1RM testing protocol, involving 3–5 repetitions at a challenging load on a pin-loaded seated calf raise machine; estimated 1RM values were derived using the Baechle & Earle [5] equation to ensure participant safety. Participants also recorded sessional data, including repetitions, load, and rate of perceived exertion (RPE), to

monitor progression and ensure training consistency. Data were analyzed using repeated measures ANOVA to evaluate within-group and between-group differences in muscle hypertrophy and strength, with significance set at  $p \leq 0.05$ .

## III. RESULTS AND DISCUSSION

### A. Effects of Range of Motion (ROM) Training on Gastrocnemius Hypertrophy and Strength

A statistically significant improvement in estimated 1RM performance was observed across all groups in Table I. The FULLROM group increased from  $48.3 \pm 5.61$  kg to  $57.9 \pm 5.13$  kg ( $t = -18.5$ ,  $p < 0.001$ ,  $d = 5.84$ ), the INITIALROM group from  $47.5 \pm 4.28$  kg to  $57.8 \pm 4.45$  kg ( $t = -10.9$ ,  $p < 0.001$ ,  $d = 3.44$ ), and the FINALROM group from  $49.7 \pm 5.05$  kg to  $59.5 \pm 5.23$  kg ( $t = -14.5$ ,  $p < 0.001$ ,  $d = 4.58$ ). These substantial strength gains align with previous literature indicating that untrained individuals typically experience rapid neural adaptations during the initial weeks of resistance training, including increased motor unit recruitment and improved neuromuscular coordination [6].

In terms of hypertrophy, all ROM groups showed significant increases in gastrocnemius girth. The FULLROM group improved from  $36.8 \pm 1.49$  cm to  $38.5 \pm 1.56$  cm ( $t = -11.6$ ,  $p < 0.001$ ,  $d = 3.66$ ), the INITIALROM group from  $36.7 \pm 1.35$  cm to  $38.6 \pm 1.40$  cm ( $t = -21.1$ ,  $p < 0.001$ ,  $d = 6.66$ ), and the FINALROM group from  $36.6 \pm 1.39$  cm to  $38.3 \pm 1.43$  cm ( $t = -14.8$ ,  $p < 0.001$ ,  $d = 4.67$ ). The greatest mean difference was observed in the INITIALROM group, supporting the hypothesis that training at longer muscle lengths promotes greater stretch-mediated hypertrophy due to increased mechanical tension in lengthened positions [1][2].

TABLE I  
PAIRED SAMPLES T-TEST RESULTS FOR PRE-POST GIRTH AND 1RM STRENGTH ACROSS ROM GROUPS

Group	Variable	Mean Difference	t(df)	p-value	Cohen's d
FULL	Girth	-1.67	-11.60(9)	< 0.001	-3.66
	1RM Strength	-9.65	-18.50(9)	< 0.001	-5.84
INITIAL	Girth	-1.88	-21.10(9)	< 0.001	-6.66
	1RM Strength	-10.34	-10.90(9)	< 0.001	-3.44
FINAL	Girth	-1.70	-14.80(9)	< 0.001	-4.67
	1RM Strength	-9.88	-14.50(9)	< 0.001	-4.58

Although all groups demonstrated significant improvements, a mixed ANOVA in Table II revealed a significant main effect of group ( $F(2,27) = 5.69, p = 0.009, \eta^2_p = 0.296$ ).

TABLE II  
MIXED ANOVA RESULTS

Source	df	F	p-value	Partial $\eta^2$
Time (Girth)	1, 27	654.77	0.000	0.960
Group	2, 27	5.69	0.009	0.296
Time $\times$ Group	2, 27	0.89	0.424	0.062

Post-hoc analysis in Table III indicated a significant difference between FULLROM and FINALROM ( $p = 0.007$ ), but no significant difference between INITIALROM and either of the other two groups. This suggests that, while INITIALROM showed the largest individual gains, within-group variability may have obscured statistically significant differences between groups.

TABLE III  
POST HOC PAIRWISE COMPARISONS (BETWEEN GROUPS)

Comparison	Mean Diff	p-value	95% CI
FULL vs. FINAL	1.227	0.007	[0.297, 2.157]
FULL vs. INITIAL	0.567	0.393	[-0.363, 1.497]
FINAL vs. INITIAL	-0.660	0.243	[-1.590, 0.270]

These findings align with prior studies showing that ROM can critically influence hypertrophic adaptations [2]. Specifically, partial ROM at extended muscle lengths (INITIALROM) may offer a hypertrophic advantage, particularly for biarticular muscles such as the gastrocnemius, due to sustained mechanical tension and favourable sarcomere length conditions [3]. Overall, these results affirm the effectiveness of resistance training for gastrocnemius development in untrained individuals and highlight that ROM selection can significantly affect strength and hypertrophy outcomes. This holds practical relevance for designing targeted training programs based on specific anatomical or performance goals.

#### IV. CONCLUSIONS

Training in the initial range of motion significantly enhances gastrocnemius hypertrophy and strength in untrained males. These findings challenge the traditional emphasis on full ROM and support emerging evidence favouring lengthened-position training. This has practical implications for optimizing resistance programs targeting the calf muscles using accessible, field-based methods.

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