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Case Report
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Effects of Six Weeks of Training at Different Ranges of Motion on Gastrocnemius Hypertrophy and Strength: A Case Study

Arthur Brum Gonçalves Bischoff[1], Maria Eduarda Cechella Rigo[1], Vanessa Ines Wenzel[2], Lorenzo Laporta[1,3] and Gustavo Ferreira Pedrosa[1]*

[1]*Grupo de Pesquisa Aplicada ao Treinamento de Força (GPATF), Centro de Educação Física e Desportos (UFSM), Santa Maria, Brasil*

[2]*Grupo de pesquisa em Biomecânica e Energética do Movimento Humano (GPBEMH), Laboratório de Biomecânica (LABIOMEC), Centro de Educação Física e Desportos (UFSM), Santa Maria, Brasil*

[3]*Núcleo de Estudos em Performance Analysis Esportiva da Universidade Federal de Santa Maria (NEPAE/UFSM), Santa Maria, Brasil*

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***Corresponding author:** Gustavo Ferreira Pedrosa, Research Group Applied to Strength Training. Center for Physical Education and Sports of Federal University of Santa Maria (UFSM). Av. Roraima, 1000 - Camobi, Santa Maria, Brazil

Abstract

Introduction: The discussion regarding the influence of range of motion (ROM) on muscle hypertrophy following resistance training has increased. However, there is still limited data on the impact of varying the range of motion on muscle hypertrophy.

Methodology: This study compared within-subject (study case) the hypertrophy of the medial gastrocnemius muscle and the strength increase after 6 weeks training the calf raise exercise performed in the horizontal leg press machine. For this purpose, an experienced volunteer trained one leg using full ROM (FULLrom) and the other leg using varying ROM (VARrom) across the training sessions, encompassing both the initial partial ROM (INITIALrom) and the final partial ROM (FINALrom). Ultrasound images of the middle cross-sectional area (CSA) of the medial gastrocnemius were taken before and after training, along with a strength test (10-repetition maximum: 10RM test). Absolute data in percentile changes between pre- and post-training were used to verify differences in CSA, and the 10RM test.

Results: The FULLrom leg showed a 4.14% increase in CSA, while the VARrom leg showed a 0.02% increase in CSA. In the 10RM test, both legs performed equally with an increase of 20.18% after the training period.

Conclusion: The following data might suggest that training at FULLrom is superior for the hypertrophy of the medial gastrocnemius compared to training in VARrom, but not for strength increase.

Keywords: Varying ROM; Resistance Training; Volume Load; Muscle Strength; Cross Sectional Area

Introduction

Physical activity in general has been demonstrated to be a powerful tool for controlling a variety of chronic diseases, preventing some causes of death, and prolonging life with a better quality of life [1,2]. Moreover, resistance training is still one of most types of physical activity practiced across years, even during the pandemic and post-COVID worldwide situation [3]. The effectiveness of resistance training relies on controlling training variables such as frequency, volume, proper execution, and intensity, in accordance with training principles [4,5]. In line with this reasoning, manipulating training variables may result in different responses in muscle hypertrophy and strength adaptations [6-9]. Therefore, researchers have sought to understand how to manipulate training variables to optimize adaptations in muscles such as the gastrocnemius muscles [10-15].

However, there is limited evidence regarding the effects of manipulating the range of motion (ROM) on strength and hypertrophy responses in gastrocnemius. Previous findings have shown that training with a lengthened partial ROM (longer muscle length contractions: INITIALrom) seemed to be superior to training with a shortened partial ROM (shorter muscle length contractions: FINALrom) and was comparable to or even surpassed full ROM (FULLrom) in inducing muscle hypertrophy in the gastrocnemius, as well as in other muscles [16]. A possible reason for this occurrence seems to be associated with the difference of the tension production in lengthened versus shortened muscle positions [17-20]. Evidence shows higher levels of phosphorylation of mechano-responsive kinases (Akt and p70S6K) after contractions at longer compared to shorter muscle lengths [21]. Furthermore, greater IGF-1 concentrations were identified after training at longer muscle lengths, in contrast to shorter ones [22].

Allowing to speculate that the physiological responses triggering muscular hypertrophy occur to a greater extent from the mechanical stress induced at lengthened ROM compared to those occurring at shortened ROM. FULLrom and INITIALrom protocols incorporate the lengthened muscle position, which might explain the effectiveness of these training approaches. New ROM manipulation has been tested with notable results for strength and hypertrophy development. This approach involves varying the ROM during training (VARrom), with one session focusing on INITIALrom and another on FINALrom [23-25]. The strategy allows a focus on individual components of the trained ROM, which improved quadriceps muscles strength and adaptation to the same extent as FULLrom. According to a previous study, the greater volume load (total weight lifted across sessions) progression observed in partial ROM training could explain the quadriceps strength and hypertrophy results of VARrom compared to FULLrom, as volume load progression has been associated with hypertrophy [26].

Corroborating with these results, greater gastrocnemius hypertrophy, along with increased volume load progression, has been observed in the INITIALrom group compared to the FULLrom group. However, the FINALrom group showed a greater volume load progression than the FULLrom group but did not exhibit greater gastrocnemius hypertrophy, suggesting that volume load progression is not the only factor that matters. Considering that, a training program that consists in a VARrom training protocol and focuses on the load progression throughout the training sessions could clarify the adaptation for hypertrophy and strength of the gastrocnemius muscles. Hence, this case study was conducted to investigate the impacts of a 6-week training regimen on hypertrophy of the medial gastrocnemius muscles and the enhancement of strength in the plantar flexion movement by FULLrom and VARrom training protocols. Our hypothesis posited that there would be no discernible difference in the hypertrophy of the medial gastrocnemius muscles and performance in the strength test between the two ROM training protocols.

Case Report

The sample was selected by convenience, as it involved a resistance-trained individual with over 10 years of practice and accustomed to training the gastrocnemius muscles. The volunteer was informed about the study procedures, contraindications, and possible side effects before starting the study. Table 1 informs the volunteer's profile (Table 1).

Overall Study Design

The study took place over 23 sessions with six weeks of training (18 sessions) in the calf raise exercise in a horizontal leg press machine, where one leg was subjected to the VARrom protocols and the other to the FULLrom protocol. Before and after the training period, images of the CSA of the medial gastrocnemius muscle were obtained via ultrasound to assess muscle hypertrophy. Additionally, strength performance in the full ROM was analyzed using a unilateral 10 RM test to identify strength gains. Figure I illustrate the study design (Figure 1).

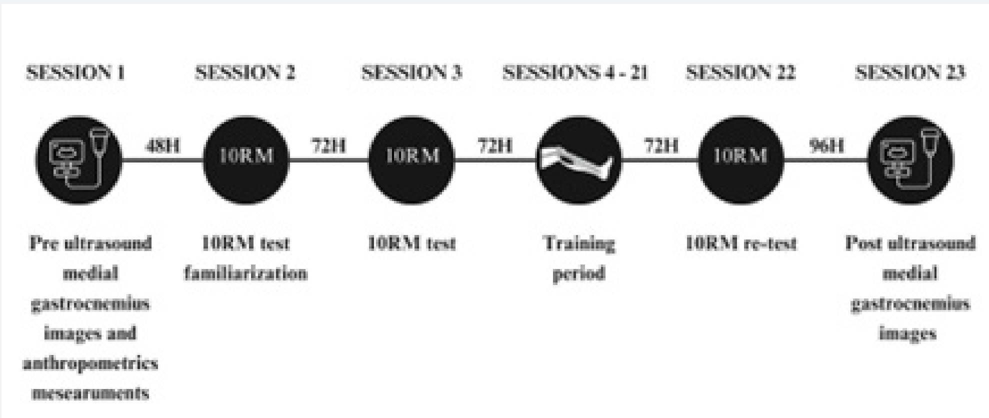

Figure 1: Study Design.

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Table 1: Volunteer Profile.

Age (years)	Height (cm)	Weight (kg)	Time of Experience (Years)	Body fat (%)
24.7	186	94.4	10.5	13.6

Session's Procedures

1st Session: Pre-ultrasound images and anthropometrics measurements - On the first day of data collection, the volunteer underwent anthropometrics measurements by the skin folds method [27] and medial gastrocnemius CSA using ultrasound. The images of the CSA of the medial gastrocnemius were taken in the proximal third between the lateral femoral epicondyle and the lateral malleolus of the fibula [28] in the medial-lateral direction of each leg, after the volunteer lay in a prone position for 10min for fluid accommodation. The images were captured at a frequency of 21 frames per second using a 10 MHz linear transducer with a depth of 6cm and a brightness of 13dB, transmission gel was used as needed to improve image quality and the B-mode of ultrasound (Siemens Healthcare, ACUSON S200, Germany) was utilized. Two technicians previously trained in ultrasound were responsible for the images. The images were saved on a pen drive for CSA calculation using Horos® software (Annapolis, Maryland, USA).

2nd Session: Familiarization with the 10RM test – The volunteer performed a unilateral 10RM test on both legs in the FULLrom (+25º to -25º, with a goniometer used during the warm-up to help the volunteer become accustomed to the ROM) in the gastrocnemius raise horizontal leg press machine, following previous recommendations. The 10RM test began with a warm-up, where the volunteer performed one set of 10 repetitions at 50% of their self-estimated unilateral 10RM for each leg, with a 60s rest interval between legs. The stipulated tempo was 2s for the concentric phase and 2s for the eccentric phase. Two minutes after the last repetition of the warm-up, the volunteer initiated the familiarization of 10RM test with their estimated 10RM load to the test. The unilateral 10RM test familiarization was performed throughout a FULLrom, with a 3min recovery interval between attempts, alternating legs (right leg first, previously randomly determinate). A final value was obtained within 6 attempts. Comparisons between the 10RM tests were made between pre- and post-condition with the same leg and between legs.

3rd Session: 10RM test - This session occurred 72h after the last session. In this, a sole 10RM test was conducted, following the procedures previously established during the 10RM test familiarization.

4th to 21st Session: Training period - This session took place 72h after the third session. Two different training protocols were utilized, conducted in a cross-over format over a period of 6 weeks training, three times per week, totaling 18 training sessions. The exercise consisted of plantar flexion on a horizontal leg press machine. The warmup was 1 set of 10 repetitions with the 50% of 10RM value, in the beginning of all session in the specified ROM. After the warmup, the volunteer performed 3 sets with a repetition range of 8 to 12 submaximal repetitions with 90% of the 10RM test load, leaving 1-2 repetitions in reserve (RIR) [29], adjusting the weight by approximately 5% whenever one complete repetition beyond the proposed range was achieved. A cadence of 2s for each phase of the movement was recommended. The rest interval between sets was set in 120s.

The volunteer performed the exercise with knees extended and feet positioned on the platform, supported by the metatarsals. Sessions were conducted with one leg using a FULLROM protocol (FULLrom -25º to +25º) relative to the neutral position (0º ankle flexion), while the other leg followed a VARrom alternating between both partial ROM, INITIALrom (-25º to 0º) and FINALrom (0º to +25º) during the training sessions as shown in Figure II. The training always started with the FULLrom leg, altering with the VARrom leg with a 120s rest between sets. A manual goniometer was used to show the volunteer the ROM that he should train in each day during the warmup. To calculate volume load, we used a spreadsheet during the training period to record the weight and the number of repetitions performed in each session. The equation used to calculate the volume load was number of sets *number of repetitions* load lifted and summed across all the sessions.

22nd Session: 10RM re-test - 96h after the last training session, the volunteer replied the 10RM test following the same protocol of the 3rd session.

23rd Session: Post-ultrasound images measurements – All the ultrasound images procedures were replicated 96h after the post-training 10RM test, to avoid the effects of muscle swelling from the test [30], (Figure 2).

Results

Hypertrophy Measurements of Medial Gastrocnemius

The mean pre-values of the CSA were to the FULLrom leg 16.4430cm^2 and to the VARrom leg 17.8045cm^2. Post-training period the mean values were to FULLrom leg 17.1115cm^2 and to VARrom leg 17.8075cm^2. Representing an increase of 4.14% in the CSA to the FULLrom leg, while the VARrom leg experienced an increase 0.02% in the CSA. Figure III represents the values of the CSA (Figure 3).

10RM Test

The 10RM tests for plantar flexion movement conducted in session 3 and session 22, showed equal performance in both legs on the test and re-test. At the beginning of the protocol, with 109kg, and after the protocol, with 131kg. An increase of 20.18% of strength in the 10RM test. Figure IV illustrates the results of the 10RM test (Figure 4).

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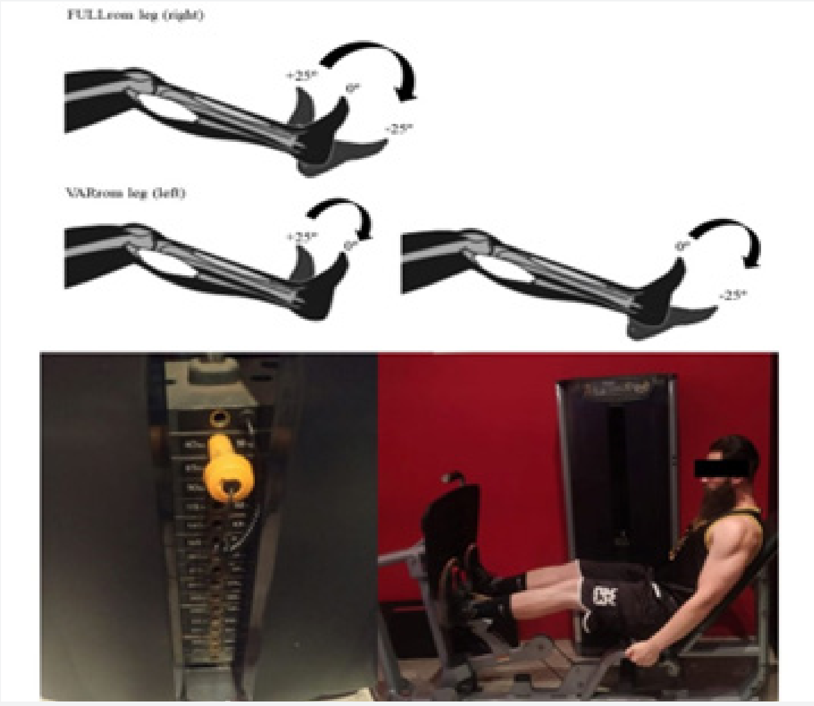

Figure 2: Training Protocols with Different Ranges of Motion.

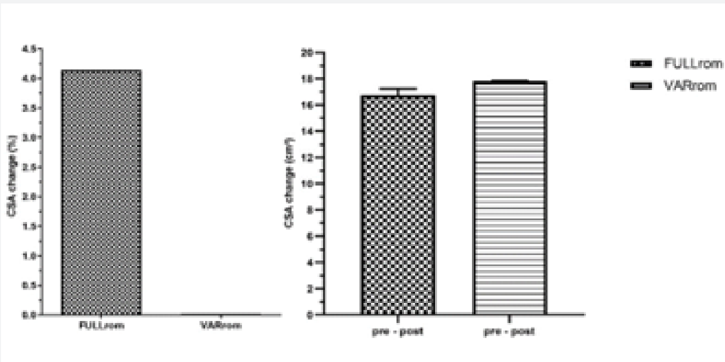

Figure 3: Mean CSA Values of Medial Gastrocnemius.

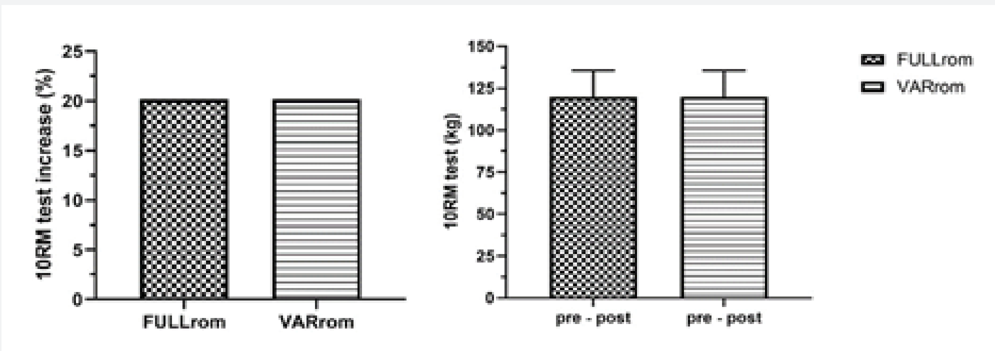

Figure 4: Results of the 10RM Test.

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Total Volume Load

The results for volume load over the 6 weeks were 61444 kg for the FULLrom leg and 68837 kg for the VARrom leg, a difference of 7393kg between legs. Figure V represents the total volume load.

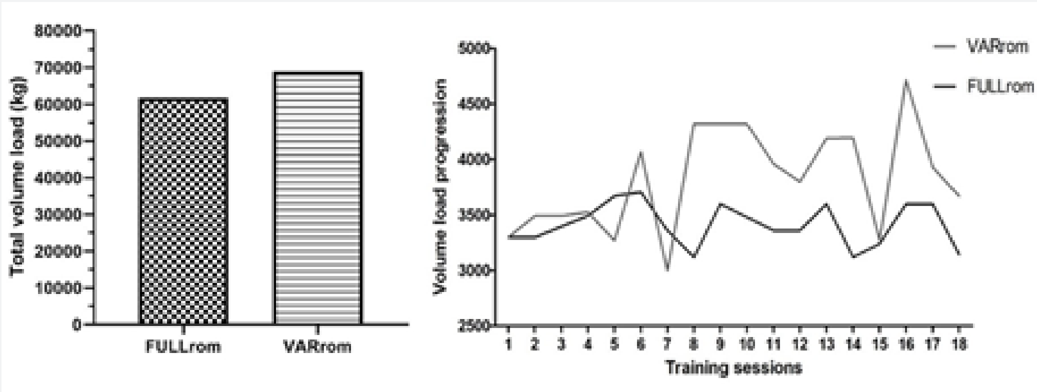

Figure 5: Results of Total Volume Load and Volume Load Progression During the 18 Training Sessions.

Volume Load Progression

The progress of volume load throughout the sessions reveals a difference between the legs, where the VARrom leg managed to progress more than the FULLrom leg, particularly on days when training involved FINALrom. Figure V shows the session's volume load progression during the training period (Figure 5).

Discussion

The aim of the present case study was to compare the hypertrophy of the medial gastrocnemius muscle after 6 weeks training one leg in the VARrom and the other leg in the FULLrom. Our initial hypothesis assumption that there would be similar gains between VARrom and FULLrom was not confirmed, given that there was more favorable gastrocnemius muscle hypertrophy for FULLrom leg. The main finding showed a superior increase in the CSA of 4.14 % in the leg that trained in FULLrom compared to the leg that trained in VARrom. Potential mechanisms and explanation for this result is that the VARrom leg underwent half of the training sessions without subjecting the muscle to contractions at lengthened positions, which has been seen as favorable strategy for hypertrophy. Controversially, in Pedrosa et al. The VARrom group trained half the sessions in the shortened position and have no differences in the hypertrophy between the FULLrom, conflicting with the findings of this study.

Furthermore, the VARrom group found a slightly more favorable response in regional hypertrophy in distal portions compared to the FULLrom group. In the present study, the analyses of gastrocnemius medial occurred only at 30% proximal, which could limit the discussion about the regional hypertrophy, suggesting that the VARrom had a similar increase in the CSA, in general, to the FULLrom because it was able to train with the same time under tension at longer muscle length compared to FULLrom. However, this similarity was not observed in the present study, even with the equalization of time under tension between the protocols. It is worth noting that the muscles evaluated in Pedrosa et al. Were the rectus femoris and vastus lateralis, while in the present study, the medial gastrocnemius was assessed. Therefore, it is possible that muscles may respond differently to training protocols with variation in ROM. Based on our findings, the medial gastrocnemius responds better in hypertrophy to training in FULLrom when compared to VARrom.

There is evidence that increasing volume load over a training period may result in greater hypertrophy findings which is controversy to the finding of our study. The VARrom leg had a higher total volume load and a minor CSA change. These findings can be discussed amount the load progression of the partial's ROM, especially during the FINALrom training day. It was noticed the FINALrom training could perform the exercise with a higher load than the INITIALrom and the FULLrom. However, on the FINALrom day, the gastrocnemius muscle was in a shortened position, which is typically considered suboptimal for hypertrophy. The results in volume load finding in our study are supported by the findings in Kassiano et al, where the partials ROM performed a greater volume load compared to the FULLrom. It is worth noting that if the VARrom condition was trained with heavier weights but resulted in lesser hypertrophy, it may be speculated that strength gains in this condition were more dependent on neural mechanisms rather than morphological muscle changes [30,31].

The result of the 10RM test indicates that both protocols were equally effective in improving strength performance. Both protocols trained with a repetition range between 8-12, with higher absolute values for the VARrom condition. However, the

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FULrom protocol trained daily covering twice the angular distance compared to the VARrom protocol. Therefore, it is possible that a balance occurred between the two protocols regarding strength gains, as while one trained with greater absolute intensity, the other trained with greater displacement. These results are consistent with previous study where the FULLrom and VARrom groups showed similar gains in maximum strength in the leg extension exercise tested in the FULLrom. Unfortunately, no other study using VARrom was found, limiting the discussion to the results found in the present study and the previous one. Thus, collectively, it seems that both ROM manipulation strategies are equally effective in increasing strength performance in a full ROM spectrum.

Conclusion

The following data may suggest that training in FULLrom is superior for hypertrophy of the medial gastrocnemius compared to VARrom and does not result in differences in the 10RM test throughout the 6-week training sessions.

Limitations

The present study has several limitations that should be taken into consideration. There was no control over dietary intake during the 6-week training period, which may be considered a relatively short duration to extrapolate hypertrophy results. Studies with longer durations should be conducted with greater sample size. Additionally, this study only analyzed a portion of the gastrocnemius muscle, and the responses of other muscles and regions may differ. Considering that, further investigations should be conducted to better understand the effects of ROM manipulations on gastrocnemius muscle.

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