ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

EFFECTS OF PARTIAL RANGE OF MOTION EXERCISE IN ECCENTRICALLY LOADED MUSCLES – A LITERATURE REVIEW

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Article DOI: https://doi.org/10.36713/epra22810
DOI No: 10.36713/epra22810

ABSTRACT

Resistance training plays an important role in improving muscle hypertrophy and enhancing performance in sports field such as athletes, bodybuilders, power lifters etc. This review investigates the impact of full versus partial range of motion (ROM) during resistance training (RT) on muscle hypertrophy and strength gains, while exploring the mechanisms underlying strength improvements in longer muscle length training. A comprehensive literature search was conducted across databases such as Google Scholar, PubMed, and ScienceDirect, focusing on articles published between 2019 and 2025. Studies were selected based on specific criteria, such long muscle length training and English language full-text availability, resulting in 29 articles for detailed (qualitative) analysis. The findings suggest that training at longer muscle lengths is an effective way to increase muscle hypertrophy, torque generation, and neuromuscular efficiency compared to full ROM exercises. Training at longer muscle lengths promotes longitudinal muscle growth, potentially inducing greater hypoxic conditions, leading to superior hypertrophy and making it effective for overcoming muscle growth plateaus in trained individuals. Further research is needed to explore the mechanisms and limitations of partial ROM training, particularly regarding cable machine exercises, trunk musculature, and trained individuals, as well as a clearer explanation of the mechanism of greater muscle hypertrophy in longer muscle length training. Individualized approaches are recommended to balance discomfort with effective adaptation strategies. In conclusion, resistance training protocols should prioritize exercises at longer muscle lengths to optimize hypertrophy, strength, and neuromuscular adaptations.

KEYWORDS - *Partial Range Of Motion, Full Range Of Motion, Longer Muscle Length, Resistance Training, Muscle Hypertrophy*

INTRODUCTION

Resistance training is commonly employed to enhance muscular strength and promote both neural and structural changes within the body [1]. Resistance training (RT) is widely utilized to promote muscle growth, enhance strength, and boost athletic performance. It plays a significant role in numerous sports, especially those where increased muscle mass is a key factor for success, such as bodybuilding [2]. Resistance training exercise technique refers to the deliberate and precise performance of movements to efficiently engage targeted muscle groups while reducing the likelihood of injury. This includes proper body alignment, posture, range of motion (ROM), and the speed at which repetitions are performed [3].

Recent research indicates that performing partial range of motion (pROM) exercises at the beginning of the concentric phase when the muscle is in a lengthened state leads to greater muscle growth than doing partial range at the end of the range, when the muscle is shortened. In fact, this method may be just as effective, if not more so, than using a full range of motion during training [4]. Research on muscle behavior at varying lengths in humans has shown that, during electrical stimulation, a higher frequency is needed to achieve tetanic fusion in shortened muscles compared to lengthened ones. This is attributed to the quicker contractile properties of muscles when they are in a shortened state [5]. Regional muscle hypertrophy is influenced by factors like exercise selection, repetition schemes, movement tempo, and training at different muscle lengths. Across studies, muscle force appears to play a key role in determining which region of the muscle grows [6]. When comparing the results, it becomes evident that training at extended muscle lengths, whether through FULLROM or INITIALROM, often leads to increased muscle hypertrophy [7]. A study found that eccentric contraction (ECC) of the elbow flexors with a larger range of motion (ROM) resulted in more significant muscle damage compared to a protocol involving a smaller ROM [8].

However, the type of muscle contraction may impact the results. Research has shown that eccentric leg extensions tend to primarily engage the rectus femoris, with limited muscle growth seen in the Vastus group. Additionally, earlier studies indicate that eccentric exercises may promote greater hypertrophy in the lower (distal) region of the quadriceps femoris [9]. The triceps brachii is crucial for elbow extension and plays a key role in sports like baseball, tennis, and shot put, as well as injury prevention. The long head of the triceps crosses both the shoulder and elbow joints and is lengthened more in an

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overhead arm position. While overhead and neutral elbow extensions are commonly used exercises, their effects on hypertrophy are rarely compared [10]. Another study involving young women performing calf raises with different ranges of motion—full ROM (−25° dorsiflexion to +25° plantar flexion), lengthened partial ROM (−25° to 0°), and shortened partial ROM (0° to +25°)— greater increases in medial gastrocnemius muscle thickness were found in the lengthened partial ROM group[13]. Notably, the full ROM group reached momentary failure during the final portion of the movement, from around 0° to +25° plantar flexion [11]. A study found that using a cambered barbell during the bench press led to a significantly greater time under tension compared to the standard barbell, even though the number of repetitions was the same. This increase was attributed to the longer range of motion provided by the cambered bar [29].

Although both PROM and FROM training methods have been shown to enhance strength, FROM is often more widely supported and encouraged as the conventional approach [13]. A study comparing full (0°–120°) and partial (45°–90°) ROM triceps training over 8 weeks in trained men found that the partial ROM group showed greater gains in strength (40% vs. 24%) and muscle CSA (49% vs. 28%) [14]. However, the mechanism underlying the improvements in partial ROM training was unclear, and if the partial ROM exercises are equally effective in trained individuals. Hence, the aim of this literature review is to compare the effects of full ROM vs partial ROM on muscle hypertrophy and strength and find out the optimal techniques for better improvements. We also focused on finding out the underlying mechanism of strength improvements in longer muscle length training.

LITERATURE REVIEWS

The objective of the experimental based study was to find out how training quadriceps at different hip flexion angles , affects the strength of Rectus Femoris and vastus lateralis [9].The researchers conducted a study where they included 30 untrained male participants and randomly assigned every participant's lower limb to either 40 degrees of hip flexion or 90 degrees of hip flexion based seated knee extension. The participants were guided by the researchers to train their unilateral leg for 10 weeks (2 sessions per week), where they included 3 sets of knee extension exercise with a rep range of 15-20 repetitions in each session (progressed to 4 sets from 2nd week). The researchers assessed both muscle thickness(using B-mode ultrasound, at rectus femoris and vastus lateralis)and muscle strength before and after the first and last training sessions .They observed that the participants who trained at 40 degrees of hip flexion showed significant increase in muscle strength and thickness in rectus femoris, but found no significant difference on vastus lateralis muscle thickness Between both the groups . According to the authors, the potential stimulus proposed about the favorable hypertrophic outcomes when the muscle is trained at longer-muscle lengths are greater increase in resting IGF-1 levels and Greater muscle deoxygenation. The authors also highlighted some limitations in their research such as it was not possible to ensure that participants performed the leg Extension exercise with precisely 40° of hip flexion due to Equipment limitations. The descriptive analysis of this study shows that training at longer muscle length in seated knee extensions significantly improves rectus femoris muscle size and strength.

The aim of this research was to observe the effects of exercising in different range of motion on muscle size and muscle strength[22]. The researchers conducted an experiment where the participants trained both their upper limb in shortened and lengthened muscles lengths (i.e., one arm in long muscle length, another arm in short muscle length.) They included twenty-one untrained female participants in the study, out of which 19 women completed the study (Age – 22+_ 10 years). The authors designed a training protocol consisting of preacher curls performed on both sides of the arm, with training sessions (Three training sessions per week)conducted for six weeks .The researchers guided Half of the participants to train their preferred limb in longer muscle length (0-68)and the opposite limb in shorter muscle length (68-135 degrees),whereas the other half of the group to train their preferred limb with shorter muscle length(68-135 degrees) and opposite limb with longer muscle length (0-68 degrees) . During assessment, they found a significant improvement in both groups, specifically in the muscle strength and muscle size of the limb which was trained in the initial ROM compared to the limb trained in the final ROM. The examiners assessed both the muscle size (Using B-mode ultrasound) and muscle strength (using 1 RM testing) before and after the first and last training session. The authors found a significant improvement in muscle hypertrophy and muscle strength in the upper limb trained with long muscle length (i.e., initial ROM) compared to the upper limb trained with short muscle length (i.e., final ROM). Authors explain that a possible mechanistic explanation for the heightened regional hypertrophic response is related to the production of higher amounts of metabolic Stress, and insulin-like growth factor (IGF)-1 release when training at longer muscle Lengths in comparison to training at shorter muscle lengths. The researchers also mentioned some limitations in the study stating that the small sample size and lack of long term follow up on strength retention, may limit generalization to large population. The article concludes by stating that training arms at longer muscle length (Initial ROM) improves both muscle strength and muscle size Rather than training at shorter muscle length (Final Rom).

A systematic review-based study aimed to examine the effects of resistance training in different ranges of motion (ROM) on muscle hypertrophy [4].The authors focuses on addressing the knowledge gap in practical guidlines regarding the optimal range of motion for maximizing muscle hypertrophy. The authors collected a total of two thousand five hundred and thirty-two studies, through sources such as PubMed, Medline, Scopus etc and ultimately eleven studies were included after screening. The inclusion criteria considered by the authors consisted of healthy participants who were either trained or untrained individuals and free weight or machine-based exercises were performed. The methodological quality of the included articles were assessed using the modified Physiotherapy Evidence Database (PEDro) scale. In the results, the authors found out that for the biceps brachii, partial ROM

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training in a lengthened position led to greater hypertrophy than full ROM, which was superior to partial ROM in a shortened position. For the triceps brachii, they found no significant difference between full and partial ROM training. In quadriceps training, the researchers observed that full ROM and partial ROM in a lengthened position improved rectus femoris thickness, but vastus lateralis showed no significant changes. In squat exercises-based research studies, the authors found that full ROM squats led to the greatest hypertrophy in gluteus maximus, rectus femoris, and vastus lateralis, while deep squats favored vastus lateralis and rectus femoris growth, and partial squats resulted in the least hypertrophy. The authors concluded that partial ROM training in a lengthened muscle position can be equally or more effective than full ROM training for muscle growth and also mentioned some limitations in their systematic review such as, lack of studies on hamstrings and hip adductors, limited data on trained individuals or athletes, and the predominant use of free weights, which places the highest load in lengthened positions. Suggestions were also given by the authors regarding the future research which should explore the effects of partial ROM training using cable machines, where tension is highest in the shortened position, to better understand its impact on muscle development.

The article focuses on finding out the effects of hip and knee joint positioning on the MVIC(Maximum voluntary isometric contraction), EMG, neuromuscular activity, muscle architecture, TAC (tendon aponeurosis complex) stiffness of the quadriceps muscle [24]. The authors state that Quadriceps muscle weakness is frequently associated with knee pain and early degenerative changes, and Strengthening of the quadriceps muscle is shown to decrease the knee pain and slow down the degenerative changes. But the main problem which the authors faced during the strengthening exercise was the pain in the patients while exercising, throughout the ROM in the knee. Hence, they conducted a study to find out the optimal ROM for increasing quadriceps muscle hypertrophy and muscle strength. The researchers of this study included 20 healthy, untrained males (aged 18–30) who underwent four experimental conditions, testing different hip (0° or 85°) and knee (20° or 60°) joint angles. Participants completed five lab visits: one for familiarization and four for testing. The researchers tested for maximal voluntary isometric contractions (MVICs) in different joint positions, in every session and mainly used Ultrasound imaging and electromyography (EMG) to analyze muscle-tendon structure and computerized dynamometer for the purpose of torque evaluation. The authors found that Peak torque and neuromuscular efficiency of the quadriceps were higher for 60° knee flexion (in both supine and seated position)compared to 20° knee flexion (in both supine and seated position) and also observed that the tendon aponeurosis complex stiffness, tendon force, stiffness, stress, and Young's modulus were greater in more elongated positions (60◦) than in shortened positions (20°). They also highlighted some limitations in the study such as lack of estimated contributions of each Muscle for the total quadriceps muscle force, and also mentioned that the study was restricted to the healthy young male population, and further research needs to be conducted on injured patients and athletes to thoroughly study the effects of partial range of motion training. The authors concluded the study by suggesting that Clinicians should consider positioning the knee at 60◦ of flexion rather than 20◦, regardless of if seated or supine, during rehabilitation to load the musculotendinous unit.

The experimental based study investigated the regional hypertrophy, or the non-uniform growth of muscles, by analyzing the effects of inclined bicep curls (INC) and preacher curls (PREA) on different regions of the arm in recreationally trained women [6]. The study explored the concept of regional hypertrophy, which refers to the non-uniform growth of muscles due to different training stimuli. The researchers included 33 participants in the study, out of which 31 completed the study. The participants included by the researchers were aged between 18-5 years and had a training experience of atleast 6 months. They designed a 9 week of training protocol (3 sessions per week), consisting of 4 sets of 12 reps, to volitional failure. The examiners assessed the Muscle thickness using B-mode ultrasound at 50%, 60%, and 70% of the distance between the acromion and the olecranon. The authors observed that only the distal (70%) region of the PREA group experienced significant growth, while the INC group showed no significant changes. The study suggests that higher strain at long muscle lengths, as seen in the preacher curl, promotes distal hypertrophy, likely due to increased sarcomere length, greater activation of the Brachialis muscle. The lack of growth in the INC group was explained by the authors stating that it may be attributed to insufficient stimulus received at short muscle lengths, or limitations in measuring muscle growth with ultrasound instead of MRI. The researchers also highlighted a few limitations in the study stating that the results were limited to recreationally trained women and may/may not apply to men or other populations. It was also mentioned by the authors that only two exercises were analyzed , potentially restricting broader applicability across other resistance profiles. Overall, the descriptive analysis of the article shows greater gains in distal biceps hypertrophy when trained in preacher curls, compared to inclined dumbbell curls, showing the importance of training at longer muscle lengths.

The study examined the effects of isometric resistance training at different muscle-tendon unit (MTU) lengths on muscle architecture and Neuro-muscular fatigue resistance [27]. The researchers included Thirteen young adults (seven males, six females) and assigned each leg randomly to either short-length (S-group) or long length (L-group) training for eight weeks. The participants were guided to perform repeated maximal isotonic contractions until peak power decreased by 40% followed by recovery measurements at regular intervals. The examiners assessed muscle fascicle length (FL) and pennation angle (PA) using ultrasound and evaluated Neuro-muscular fatigue resistance using isometric maximal voluntary contraction (MVC) torque and isotonic peak power before, immediately after, and at multiple time points post-fatigue. The Results found in the study showed that both groups experienced increased PA, but only the longer muscle length group had an increase in FL and a minor improvement in neuromuscular efficiency compared to shorter muscle length group. The authors found similar Recovery patterns between both the groups. The study also mentioned a few limitations as it solely

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EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

focused on the tibialis anterior muscle , which may not represent adaptations in other muscles or functional movements and that the small sample size may limit the generalisability of the study. The authors concluded stating that training at longer muscle length has a significant effect on muscle architecture and muscle contraction, but no significant changes in fatigue resistance.

This systematic review-based study focused on examining whether longer-muscle length resistance training (LML-RT) leads to greater longitudinal muscle growth than shorter-muscle length resistance training (SML-RT) [20]. The authors explained that Resistance training (RT) enhances muscle size through mechanical overload, with hypertrophy occurring either radially or longitudinally. The authors found through recent evidences that training at longer muscle lengths may be more effective in promoting longitudinal hypertrophy. The study systematically analyzed eight studies with 120 participants, comparing LML-RT and SML-RT based on changes in fascicle length (FL) and muscle size.The articles chosen for the study purpose included the studies comparing resistance training intervention for long muscle length vs short muscle length. The authors found that LML-RT generally induced greater muscle hypertrophy and FL increases than SML-RT. The authors found that most research has focused on the vastus lateralis, limiting applicability to other muscles. The review supports LML-RT as a potentially superior strategy for muscle hypertrophy, but methodological limitations prevented firm conclusions. The researchers also mentioned some limitations and suggestions in the study stating that the future research should use direct imaging methods, examine highly trained populations, assess training at longer muscle lengths, and measure serial sarcomere number changes to confirm whether LML-RT contributes to longitudinal hypertrophy.

The study addressed the lack of clear scientific evidence regarding the mechanisms and effectiveness of specific interventions for inducing longitudinal muscle growth in humans. The authors examined factors influencing muscle length and force generation across joint angles, focusing on morphological determinants such as sarcomere arrangement, physiological cross-sectional area (PCSA), and pennation angle (PA) using a narrative review approach [28]. The authors compiled data from animal and human studies to analyze muscle adaptations to strength training, stretching, and immobilization.Data was collected by the researchers regarding the Determinants of muscle length and active force exertion, Natural muscle growth and adaptations to mechanical loading in animals and humans. The authors suggest through their findings that activities performed at long muscle lengths, including eccentric training and stretching, promote longitudinal muscle growth, while concentric and isometric training primarily enhance cross-sectional area.The study contributes to exercise physiology by Highlighting potential strategies for improving muscle function and reducing strain injuries through targeted training regimens, Providing insights into the mechanisms of longitudinal muscle growth, which could benefit wide range of population such as athletes with limited muscle extensibility. The researcher review identifies research gaps, particularly in understanding connective tissue's role in regional muscle adaptation. The study also highlights few limitations in the study stating that the mechanism driving the pennate muscle growth is still unclear. The authors conclude with their suggestion that high-intensity, long-duration interventions (over eight weeks) are necessary for meaningful muscle growth and suggests that combining stretching with strength training or electrical stimulation may offer additional benefits. The researchers also mentioned that further research is needed to optimize muscle-tendon adaptation strategies.

The researcher examined the study effects of resistance training on muscle growth, particularly focusing on the muscle's reduced ability to respond to hypoxia in long term trainees. The author compared Partial Range of Motion Exercise (PRE), which involves performing only the middle portion of a movement, and Full Range of Motion Exercise (FRE), where the complete motion is executed, to determine which method more effectively increases muscle strength and size [17]. The study also focused on determining the acute and long term effects of PRE and FRE training protocols. The author conducted the examination on Forty-four trained men (1+ year of resistance training) who were randomly assigned to lying elbow extensions , either at the PRE(45-90 degrees) or FRE (0-120 degrees), performing an elbow extension exercise for 8 weeks. The authors mainly measured muscle oxygenation (spectrometer), blood lactate levels, muscle activation (EMG), strength (dynamometer), and size (ultrasound). The researcher found that PRE led to a greater decrease in muscle oxygenation, higher blood lactate levels, and greater muscle activation compared to FRE the researcher also found that the PRE group had a significantly greater increase in triceps size (48.7%) compared to FRE (28.2%) both methods improved strength at slower speeds (120°/sec), but PRE showed superior isometric strength gains, with no significant difference in high-speed strength (200°/sec) . The author concluded the study stating that PRE is more effective than FRE for increasing muscle strength and size in trained individuals, likely due to the sustained muscle tension and induced hypoxic conditions, making it a beneficial training strategy for overcoming muscle growth plateaus. The authors also mentioned few limitations in the study stating that the study suggested a link between hypoxia nad hypertrophy , buy did not fully elucidate the underlying mechanisms. Additional studies are suggested by the authors to explore the signaling pathways which could provide further insights.

The researchers conducted a study about how different resistance training exercises influence muscle strength and growth, particularly focusing on strength gains at specific angles and muscle hypertrophy at varying muscle lengths [23]. The articles reviewed by the authors of this article suggested that training at longer muscle lengths can enhance strength and hypertrophy. Hence, they conducted a study comparing preacher curls performed with a cable (CAB) versus a barbell (BAR) in untrained young adults. The researcher conducted 10 weeks of training sessions .35 participants (aged 18-35) were guided by the researchers to perform preacher curls three times a week, completing 3 sets of 8-12 repetitions with progressively increasing weights. The researchers then measured the strength at 20°, 60°, and 100° elbow flexion using a dynamometer, while

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Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

muscle thickness was tracked via ultrasound. As the author investigated, the results showed that both exercises led to similar strength gains and muscle growth, with no significant difference in improvement in hypertrophy of both the groups, except for slightly better strength gains at 20° in the BAR group . The authors observed that men and women responded similarly to both training methods and concluded the study stating that both cable and barbell preacher curls are equally effective for improving biceps strength and size. The study also states that as the study was conducted on a small sample size, and only focused on biceps brachii, findings may/may not apply to other muscles or exercises. The authors concluded suggesting that either variation can be included in resistance training programs without a clear advantage of one over the other.

The author explored the effects of resistance training on muscle hypertrophy, focusing on training to failure and the potential benefits of performing additional partial repetitions beyond momentary failure [11]. The authors state that resistance training increases muscle mass and strength by applying mechanical tension to muscle fibers, particularly type II fibers, which are crucial for growth while training to failure can maximize motor unit recruitment and mechanical tension, it may also lead to excessive fatigue and muscular damage. This study investigated whether adding past-failure partial repetitions beyond momentary failure in calf raises lead to greater hypertrophy of the medial gastrocnemius muscle compared to training to momentary failure alone. The authors specifically examined the impact of training beyond failure in the smith machine for standing calf raise, for 10 weeks. 23 untrained men participated in the study , where the researchers measured the muscle thickness in the gastrocnemius under two conditions: DORSIVF (training to failure in dorsiflexion) and PLANTARMF (training to failure in plantar-flexion). Authors found that DORSIVF led to a greater increase in medial gastrocnemius muscle thickness compared to PLANTARMF . These findings support the idea that training beyond momentary failure, particularly in the muscle's lengthened position, enhances hypertrophic adaptations. The study involved only untrained men and focused only on the effects of exercise at gastrocnemius, limting generalizability. The nutritional intake was also not strictly controlled by the authors , which may expose the results to variability. The author conclude by stating that this method may improve muscle growth and could also increase perceived discomfort, suggesting that individual preferences should be considered when designing training programs.

The authors begin the study by mentioning that Muscle fatigue and strength performance are influenced by the range of motion (ROM) during exercise, as ROM affects muscle length and joint angles. Hence, the main aim of this article is to examine how different ranges of motion (ROM) affect strength performance and muscle fatigue in women using knee extension exercises [26]. The researchers involved 9 untrained women in the study , with average age of 24.2 years. The authors compared full ROM (FULLROM)(0-100 degrees), initial partial ROM (INITIALROM- 100-65 degrees), and final partial ROM (FINALROM- 65-30 degrees) . The Participants were also guided to complete three sets of seven repetitions at 60% of their 1 rep max for each ROM, with rest intervals between sets. The examiners also measured Maximum voluntary isometric contractions at 30 degrees and 100 degrees before and after exercise to assess force reduction as an indicator of fatigue. The results in the study found that INITIALROM and FINALROM lead to higher one-repetition maximum (1RM) performance than FULLROM. Greater force reduction was found at 30° of knee flexion than at 100°, regardless of ROM. The authors highlight the length-tension relationship, noting that muscle force varies with joint angles. The study had a small sample size and involved only to untrained women, limiting it generalizability to trained individuals.The authors also mentioned few limitations in the study stating that the study mainly focused on recording short term fatigue effects , but long term training adaptations were not recorded . The authors concluded that partial ROM improved strength performance, while fatigue depends more on joint angle than ROM selection.

Traditional resistance training emphasizes full range of motion (fROM) exercises to promote muscle growth. However, recent research has explored that partial range of motion (pROM) training, which targets specific muscle lengths and regions, potentially offers localized hypertrophic benefits. Hence, the researchers focused on this approach to observe its effects on bodybuilders seeking to improve underdeveloped muscle groups to enhance proportion and symmetry, which are the key judging criteria in bodybuilding competitions[15]. It explores whether partial ROM can enhance regional muscle hypertrophy, benefiting bodybuilders aiming for a more proportionate physique. The examiner discusses how muscle hypertrophy is non-uniform, meaning different regions respond uniquely to training. Studies suggest pROM may optimize mechanical tension at specific joint angles, potentially enhancing localized muscle growth in exercises like elbow flexion and squats. The article also highlights the length-tension relationship, explaining how training at optimal muscle lengths could improve hypertrophy. According to the guidelines favor full ROM, the authors suggest strategic partial ROM integration may complement existing training methods. This research study offers a valuable insights for bodybuilders, athletes, and trainers refining their resistance training strategies.

The article "Muscle Hypertrophy Response to Range of Motion in Strength Training" by Ottinger et al. examines how varying ranges of motion (ROM) impact muscle hypertrophy [16]. The article aims to study muscle hypertrophy mechanisms, analyze previous ROM and hypertrophy research, and propose a novel theory linking ROM effects to muscle length-tension properties.The authors argue that ROM effectiveness depends on a muscle's position on the length-tension curve, challenging the notion that full ROM is always superior. The author outlines key principles of muscle hypertrophy, including sarcoplasmic, myofibrillar, and longitudinal hypertrophy, emphasizing the role of mechanical tension at longer muscle lengths. The examiner highlights those muscles on the descending limb of the curve, like the quadriceps and hamstrings, benefit more from greater ROM, while those on the ascending limb, like the biceps and triceps, show similar growth with partial ROM. The author also indicate that deep squats lead to greater quadriceps hypertrophy than partial squats, whereas biceps and triceps

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EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

hypertrophy remains comparable across ROM variations. The article integrates biomechanical principles with applied research, suggesting that exercise selection should be tailored to muscle-specific responses rather than a universal ROM approach. The authors stress the need for longitudinal studies with trained subjects and advanced imaging techniques to validate these findings. Overall, the article presents a novel perspective, advocating for a nuanced approach to strength training based on individual muscle mechanics rather than generalized ROM principles.

Resistance training (RT) employing different ranges of motion (ROM)—full ROM (fROM) versus partial ROM (pROM)—has been extensively studied by the researchers to determine its effects on muscle hypertrophy, strength, power, sport performance, and body composition, yet consensus remained elusive. A systematic review and Bayesian multi-level meta-analysis was conducted by the authors, following PRISMA guidelines and including studies up to August 2022 [2]. The study synthesized data from various peer-reviewed articles and theses comparing fROM and pROM RT across multiple outcomes.Interestingly, the study found that partial ROM training at long muscle lengths may produce better hypertrophy benefits compared to full ROM and strength gains were specific to the ROM trained, indicating the importance of training specificity. The authors found no significant differences between upper- and lower-body adaptations. The authors explained the mechanism behind pROM hypertrophy, stating that Physiologically, pROM may induce greater muscle deoxygenation and lactate accumulation, potentially leading to distinct adaptations. The findings suggest that while full ROM generally enhances outcomes, differences are minor, making pROM a viable alternative for variation, personal preference, or injury contexts where full ROM is impractical. Limitations of this study included heterogeneity in study designs, participant profiles, and outcome measures, limited data for certain outcomes (notably upper-body hypertrophy), and potential biases in outcome assessments. Overall, both ROM strategies in the study effectively improved musculoskeletal function and morphology, with training adaptations demonstrating ROM specificity. Hence, the authors suggest that ROM choice should be designed to individual goals, sport-specific demands, and injury considerations. The authors concluded the study by suggesting further research to explore long-term effects and applicability of ROM variations in resistance training, to sport performance.

This study examined the impact of ankle joint position on the contractile properties and motor unit discharge rates of the triceps surae (TS) muscles, which include the medial and lateral gastrocnemius and the soleus [5]. The findings provide insights into how muscle length affects neuromuscular activation and may contribute to improving training and rehabilitation strategies involving the triceps surae.10 recreationally active male participants were included by the researchers in the experiment ,to perform isometric plantar flexion contractions at 2 different ROM: 20° dorsiflexion (lengthened TS) and 20° plantar flexion (shortened TS).The participants were seated with the left leg positioned in a cusutom isometric dynamometer , with hip and knee joints at 90 degrees. The examiners mainly recorded the Muscle activity using both surface and intramuscular electromyography (EMG), with electrodes placed on the tibialis anterior (TA) and Triceps surae (TS) muscles. Participants completed maximal voluntary contractions (MVCs) followed by steady-state contractions at four different intensities (25%, 50%, 75%, and 100% MVC).The authors found that shortening the gastrocnemius muscles led to a decrease in submaximal motor unit discharge rates (MUDRs) ,reducing muscle activation efficiency and found that the soleus muscle showed minimal changes in MUDRs and recruitment thresholds, regardless of the knee position. The study included only males , which may/may not limit its applicability to women or untrained populations. Furthermore , the researchers in this study mainly focused on assessing isometric contractions , due to which the findings may not fully reflect dynamic or functional performance of the muscles. Hence, the authors conclude the study by suggesting further researches to be conducted to elucidate the role of muscle length in neuromuscular control.

The authors begin by mentioning the extensive research established to find out the role full ROM training in enhancing hypertrophy in lower body muscles. But the authors found that the findings for upper limb muscles remain limited as well as the role of ROM in the phenomenon of cross-education effect was unclear. Hence, this study mainly focused on investigating how different elbow joint angles during unilateral resistance training affect muscle strength and hypertrophy in both the trained and non-trained arms [14]. The authors included Thirty-two untrained, where all 32 subjects were randomly assigned to one of three groups: extended joint training (0°–50° elbow flexion), flexed joint training (80°–130° elbow flexion), and a control group that did not train. The authors conducted a training program for five weeks, with participants performing dominant-arm resistance exercises twice per week, where the training protocol consisted of dumbbell preacher curls in extended and flexed position. The examiners included 3 sets of 10 repetitions in each session , where the load was progressively increased from 30% to 50%(in 2md and 3rd session),50-70% in (4th and 5th session),70-80%(in 6th and 7th session),90% in (8th and 9th session),100% in the 10th session. The researchers recorded the improvement in muscle strength by recording Maximum volumetric contraction(MVC), concentric and eccentric contractions. The examiners assessed the improvement in muscle hypertrophy by using B-mode ultrasound. The researchers found that only the extension group experienced significant increases in MVC-ISO, MVC-CON, and MVC-ECC torque in the trained arm and the muscle thickness was comparatively greater in the extension-based training group. They also found that non-trained arm of the extension group also exhibited cross-education effects, with increases in MVC-ISO (15.9%) and MVC-CON (16.7%) torque, while the flexion and control groups showed no significant improvements. The study suggests that training at longer muscle lengths (extension) produces greater adaptations in both muscle strength and hypertrophy, likely due to increased mechanical tension and metabolic stress. The authors also included few limitations of the study such as small sample size limiting generalizability, exercise specificity limiting its applicability to other exercises and short training period

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Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

limiting the observation of long term effects. The study concludes that resistance training at extended joint angles is more effective than at flexed joint angles for increasing muscle strength and thickness, with additional benefits for the untrained limb (cross education effect)

The study compared triceps muscle growth after doing elbow extension exercises in two different arm positions: overhead and neutral [10]. The researchers selected 21 adults who trained for 12 weeks, with one arm in the overhead position and the other in a neutral position. The authors found improvement in both the arms, but the muscle growth was greater in the overhead position, especially in the long head of the triceps, even though the weights were lighter in that position. Overall, the authors found that training with the overhead arm position led to better muscle growth. The study involved 21 healthy young adults (14 males, 7 females, ages 23-24). None had been involved in regular resistance training in the past year. The participants were guided by the authors to train one arm in an overhead position and the other in a neutral position for 12 weeks. The authors took measurements, including MRI scans and strength tests (1RM), before and after training. Each participant was guided by the examiners to train one arm in the overhead position and the other in a neutral position using a cable machine. The researchers designed an exercise regimen involveing10 reps per set, 5 sets per arm, and twice a week. Training intensity started at 50% of 1RM and increased gradually. Strength was measured at the start and end of the study. MRI scans were done before strength tests to measure muscle size, specifically the triceps brachii. The muscle volume was calculated by measuring cross-sectional areas. After 12 weeks of training, muscle growth was greater in the overhead arm position (+19.9%) compared to the neutral position (+13.=5%). The authors found that the triceps' long head (TB Long) grew more than the other parts (TBLat+Med) in both positions. The authors suggested that overhead position, which stretches the TB Long, likely helped stimulate more muscle growth in that area. The authors found that even though the absolute weights lifted were lower in the overhead position both positions showed similar strength gains (1RM), suggesting that muscle length, not just the weight lifted, plays a significant role in muscle growth. They found that Training at longer muscle lengths, like in the overhead position, resulted in more hypertrophy, even with lighter weights. Therefore, the usefulness of PROM training in rehab or training strategies to minimize joint stress. They explain the mechanism behind it stating that it may be due to the reduced contribution of the biarticular muscle or possibly reduced blood flow, which promotes hypertrophy. The authors conclude stating that for optimal muscle growth or preventing muscle atrophy, training in the overhead position is recommended.

The author examines how exercise technique Influences muscle hypertrophy in resistance training [3]. The authors explore key factors like range of motion (ROM), repetition tempo, and exercise-specific kinematics, providing evidence-based recommendations for optimizing muscle growth. The examiner emphasizes that training at longer muscle lengths is crucial for hypertrophy, and repetition tempos between 2 and 8 seconds are effective, while both slow and fast eccentric-concentric tempos can produce results, more research is needed to determine the best approach, and also the article discusses how body positioning and movement patterns impact muscle activation but notes a lack of direct studies on strict versus lenient techniques. The author concluded that full ROM with a controlled tempo while following established kinematic guidelines. The authors concluded the article suggesting that further studies are needed to explore exercise technique variations and their effects on hypertrophy. This review provides practical insights for trainers and athletes looking to optimize muscle growth through proper resistance training techniques.

The article "Fatigue and Metabolic Responses during Repeated Sets of Bench Press Exercise to Exhaustion at Different Ranges of Motion" examines the effects of different ranges of motion on fatigue and metabolic responses in resistance-trained men [25]. The study compares full ROM, bottom half ROM, and top half ROM, in the bench press exercise, analyzing their impact on barbell velocity, repetition performance, and blood lactate levels. The author found that top ROM allowed participants to lift heavier loads and perform more repetitions compared to FULL and bottom ROM and fatigue was higher in full ROM, as shown by a greater decline in barbell velocity, with bottom ROM resulted in higher fatigue than TOP ROM, which may be attributed to differences in muscle length and mechanical load. The examiners says that these variations in performance and fatigue, blood lactate levels were similar across all ROM conditions, suggesting that metabolic stress was consistent. The author concludes that top ROM may be more beneficial for lifting heavier loads with less fatigue, while full ROM leads to greater work per repetition but higher fatigue. The study can help athletes and trainers optimize resistance training strategies based on specific performance goals.

The author examines the effects of partial range of motion (PROM) and full range of motion (FROM) triceps strength training on three-point shooting accuracy [13]. The study, a randomized controlled trial, involved 30 recreational basketball players divided into PROM, FROM, and control groups. The intervention lasted four weeks, with strength training performed twice per week using an overhead cable machine. The author indicated that both PROM and FROM training improved shooting accuracy compared to the control group, PROM showed a significantly greater improvement in the stationary three-point shooting test (S3P). The authors suggest that PROM may be more effective because it mimics the natural shooting motion, particularly in activating the medial head of the triceps, which plays a crucial role in stabilizing the shot. The examiner highlights the importance of training specificity, suggesting that targeted ROM exercises can enhance sports performance. The author concluded that PROM triceps strength training appears to be a time-efficient method to improve shooting accuracy in basketball players.

The authors in this study investigated whether eccentric (ECC) exercise with full range of motion (FROM) induces a greater magnitude of delayed onset muscle soreness (DOMS), pain, and functional limitations compared to partial range of motion (PROM) [8]. Thirty-four participants were selected by the authors

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

to perform eccentric (ECC) exercise on elbow and knee muscles using 15%, 25%, 35% of maximal voluntary isometric contraction (MVIC) with PROM (weeks 2-4) and FROM (weeks 6-8). The study conducted both Subjective and objective assessments, including activities of daily living (ADL), pain (visual analogue scale (VAS)), pain pressure threshold (PPT), and MVIC in all the participants. Through the results obtained, the researchers observed that exercise with FROM induced moderate pain in ADL, VAS, and PPT for elbow extensors and knee flexors., and also observed significant improvements in muscle strength in Full ROM group than ECC group. The study concluded that ECC exercise performed with FROM induced a higher degree of DOMS, pain, and ADL limitations than PROM, suggesting the outcomes can be used for beginners, sedentary older adults and young athletes.

The study looks at how seated and prone leg curl training affects hamstring muscle growth and how likely it is to cause muscle damage during exercise [21]. The author argues that Seated leg curl training targets longer muscles and leads to bigger growth and better protection against damage compared to prone training. The researchers mainly divided the study into 2 parts: an intervention phase where people did leg curl training and a subsequent eccentric exercise phase to check for muscle damage. Twenty young adults were selected by the researchers, who did 12 weeks of unilateral leg curl training, with one leg trained in a seated position and the other in a prone position. The authors then had the subjects to do eccentric leg curl exercises in both seated and prone positions to measure muscle size changes and damage indicators. The author used statistical analysis to compare changes in muscle size and damage indicators between trained legs and the control legs and found that the seated leg curls caused bigger hamstring muscle hypertrophy, especially in biarticular muscles. According to the research two of the training methods were shown to reduce the risk of muscle damage equally. And the Seated leg curls was found to be better at increasing hamstring muscle size, especially in the biceps femoris longus and semitendinosus. According to the research two of the training methods also protect against muscle damage in the hamstrings, especially the semitendinosus. The authors conclude by suggesting that Future studies can be used using ultrasound, diffusion tensor imaging, or micro endoscopy to measure hamstring fascicle length and explore muscle architecture changes and strain injury risk.

The authors of this article suggest that gastrocnemius muscle, which works on the ascending and plateau portions of the length-tension curve, may benefit from longer muscle lengths, potentially leading to greater hypertrophy [7]. The study compared full ROM, initial ROM, and final ROM on medial and lateral gastrocnemius muscle size changes. The researchers chose 42 young women who were randomly assigned to three training groups: full ROM, initial ROM, and final ROM. The study involved 12 weeks of calf training, with muscle thickness measured at baseline and post training using ultrasound imaging. The authors found through the results that Partial ROM training at longer muscle lengths (initial ROM) was found to induce greater gains in medial and lateral gastrocnemius muscle thickness compared to full ROM and final ROM training. The author suggests that training at longer muscle lengths with higher volume load progression optimizes muscle hypertrophy. This research also provides space for Future research which can investigate these effects in various populations and exercises targeting the calf muscles.

The study looked at how different ROMs (initial, final and full) affect muscle growth and strength [18]. The authors conducted the study to study if strength gains are linked to muscle growth in different areas and if changing ROMs affects how strong you get when you lift weights. 45 women were chosen by the researchers, where the participants trained for 12 weeks with one of four ROMs. The researchers measured muscle size and strength before and after training. According to the study the group that used varied range of motion had the biggest gains in muscle size and strength, suggesting that changing ROMs can be helpful. They also found that the training groups and muscle regions had different effects on muscle size. According to the study the Initial ROM and Varied ROM groups had bigger gains in the Rectus femoris and Vastus lateralis muscles. For the 1RM tests, the INITIAL-ROM and VARIED-ROM groups had bigger changes at the initial ROM, while the training groups had similar changes at the final ROM. The study also states that muscle size changes were linked to 1RM test results for specific muscle regions and ROMs in the INITIALROM, FINALROM, and VARROM groups. The authors also states that training at longer muscle lengths during knee extension exercises, can lead to similar muscle growth across different regions and concluded that training at longer muscle lengths, even with heavier weights, seems to be better for muscle development than training at shorter lengths. The researchers found that training at shorter muscle lengths (FINALROM) made the muscles in the closer parts of the body grow bigger than the muscles in the farther parts and training at longer muscle lengths (INITIALROM, FULLROM, VARROM) made the muscles in all parts of the body grow bigger in a similar way. The researchers found that The FINALROM and INITIALROM groups both got stronger in their respective angles but the VARROM group, which had to lift heavier weights, got bigger and stronger in the initial angle more than the FULLROM group.

The study investigated the effects of lengthened partial repetitions (LPs) compared to full range of motion (ROM) resistance training (RT) on muscular adaptations in trained individuals [19]. The researchers chose subjects, thirty resistance-trained participants were assigned to either lengthened partial or full ROM conditions in a within-participant design over an 8-week RT program, which included two weekly sessions targeting upper-body musculature. The researchers mainly assessed Muscle hypertrophy and strength-endurance using ultrasonography and 10-repetitionmaximum lat pulldown testing. The research indicated that both training methods led to similar improvements in muscle thickness and strength-endurance, with Bayesian analysis providing moderate support for the null hypothesis of no significant difference. The study concluded that emphasizing the stretched position, whether through full ROM or LPs, is beneficial for hypertrophy.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

This systematic review-based study investigates the effects of muscle length on NMES-induced torque, discomfort, contraction fatigue, and strength adaptations in healthy and clinical adult populations [29]. The authors state that NMES effectiveness depends on muscle length (joint angle), which influences force generation, yet no comprehensive research exists on optimal joint angles for NMES application. The authors identified 36 relevant studies from an initial pool of 1185 articles, including 448 healthy young participants, six individuals with spinal cord injuries, and 15 older adults. Through Meta-analyses, the authors found that the optimal quadriceps muscle length (50˚-70˚ knee flexion) produced the highest evoked torque, while shorter muscle lengths led to greater discomfort and longer lengths resulted in higher fatigue. The researchers observed that NMES at optimal muscle length was associated with greater strength gains than at shorter lengths and highlighted that NMES should be applied at optimal muscle lengths to maximize force production and minimize discomfort. The researchers suggest that further detailed research is needed to refine NMES strategies.

The study investigates how the range of motion (ROM) in resistance exercises impacts training volume of the bench press performed with a cambered barbell (which allows a greater ROM) and a standard barbell [12]. The authors stated the importance of ROM influencing the training volume for optimizing muscle growth and strength development. The examiners selected 18 trained men with at least 7.3 years of resistance training experience and trained them for three weeks, with 4 sessions per week. The researchers guided the participants to perform bench press exercises with either a cambered or a standard barbell at 50% of their one-repetition maximum (1RM). The researchers included 3 sets to muscular failure in each session and Variables were measured such as repetitions performed, time under tension (TUT), load-displacement, and peak barbell velocity. As a method of data collection, the study included a linear position transducer system for velocity and range of motion and video analysis for TUT. The authors found fewer total repetitions performed by the cambered barbell exercise group and no significant difference in total time under tension or load-displacement between both the groups. The examiners observed that Concentric TUT was significantly higher in the cambered barbell condition than the eccentric TUT. According to the study the cambered barbell allowed for higher peak velocity in early sets, likely due to the increased ROM enabling greater acceleration, but observed that this advantage disappeared in the third set, possibly due to muscle fatigue. The authors found a lower 1RM in the cambered barbell condition suggesting that greater ROM increased the mechanical difficulty. The authors concluded stating that ROM influences the number of repetitions performed but not total time under tension or load-displacement and also found that Time under tension is a better indicator of training volume than repetition count, especially when different ROMs are used. The authors also suggest that these findings are valuable for strength coaches and athletes, indicating that exercise selection should account for ROM to avoid misinterpreting training volume and effectiveness. The authors mentioned some limitations in their study stating that the study covered only pectoral muscle and Future studies should investigate other exercises (e.g., squats) and different resistance loads to for detailed information.

The article emphasizes the importance of manipulating resistance training variables to optimize strength, hypertrophy, and muscle architecture adaptations [1]. The authors state that traditional resistance training reports focused primarily on load and repetitions but ignored other variables that may significantly influence outcomes such as range of motion, time under tension, repetitions to failure, muscle focus, and inter-set rest. The article presents a conceptual review, analyzing various within exercise variables and their effects on resistance training outcomes. The authors studied the impact of various factors such as load displacement, muscle length, repetitions to failure, and the use of concentric or eccentric phases, the significance of attention focus during exercises and the rest intervals between sets The authors found out that factors like the range of movement, time under tension, and the presence of repetitions to failure play crucial roles in determining muscle adaptation. The authors observed that, different training phases (concentric vs. eccentric) and attentional focus (internal vs. external) were shown to have significant effects on muscle activation and training results. The author discusses the need for a more comprehensive approach to resistance training protocols. The authors suggest that Different strategies, such as varying the load or adjusting movement velocity, can enhance hypertrophy or strength gains. The article concludes that sports scientists and practitioners should report a wide array of within-exercise variables in their resistance training protocol which allows for more accurate tracking of training volume and better understanding of different factors influencing training outcomes. This comprehensive approach helps optimize the design of training programs and enhances the effectiveness of resistance training.

METHODOLOGY

An Introductory section was developed to provide readers an idea about the study and the significance of the study. This review focused on examining the effects of long muscle length training. Detailed research was conducted using the websites such as Google Scholar, PubMed, Medline, Pedro, Research gate and Science direct and more. The articles were collected from the year 2019 to 2025. The research articles were obtained after searching in databases using following keywords such as Partial range of motion exercise, Partial range of motion training, longer muscle length, Training at longer muscle length, hypertrophy, resistance training. Seventy-four articles were found related to the topic through websites and further scrutinizing the related articles reference lists. Twenty-nine articles were selected for detailed study, out of seventy-four articles after abstract screening. The articles were included only if the studies related to long muscle length training, article published between 2019 and 2025, the published studies were in the English language and only Full text articles were collected. The articles older than 2019 and the articles including Paralympic individuals were excluded. Articles involving Partial ROM training at only short muscle length, were excluded. The quality of the randomized control studies chosen in this study were assessed based on the scoring of PEDro scale.

ISSN (Online): 2455-3662
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Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

Implications of the major findings were also discussed in the Discussion. The review concluded with a summary of the principal findings regarding the effects of partial ROM in longer muscle length exercise and addressed the limitations of this study and suggested directions for further research. The article has been drafted following the TAILMRDCR model proposed by Kumar[30].

Table 1. The methodological quality of the studies as measured by the PEDro scale-

Author and publication year	1	2	3	4	5	6	7	8	9	10	11	Sum
Larsen S et.al , 2024	Yes	1	0	1	0	0	0	1	0	1	1	5
Pedrosa GF et.al, 2023	Yes	1	0	1	0	0	1	1	0	1	1	6
De sousa AMM et.al, 2023	Yes	1	1	1	0	0	0	1	1	1	1	7
Korta AZ et.al, 2023	Yes	1	0	1	0	0	0	1	1	1	1	6
Akagi R et.al, 2023	Yes	1	0	1	0	0	0	1	0	1	1	5
Goto M et.al, 2019	Yes	1	0	1	0	0	0	1	1	1	1	6
Nunes JP et.al, 2020	Yes	1	0	1	0	0	1	1	0	1	1	6
Larsen S et.al, 2025	Yes	1	1	1	0	0	1	1	1	1	1	8
Pedroa GF et.al, 2022	Yes	1	0	1	0	0	0	1	1	1	1	6
Hali K et.al, 2021	Yes	0	0	1	0	0	0	1	1	0	1	4
Sato S et.al, 2021	Yes	1	0	1	0	0	0	1	0	1	1	5
Maeo S et.al, 2023	Yes	1	0	1	0	0	1	1	0	1	1	6
Tsoukos A et.al, 2024	Yes	0	0	1	0	0	0	1	1	1	1	5
Mir IA et.al , 2025	Yes	1	1	1	0	0	1	1	0	1	1	7
Sadachandran CM et.al, 2021	Yes	0	0	1	0	0	0	1	0	1	1	4
Maeo S et.al, 2020	Yes	1	0	1	0	0	1	1	1	1	1	7
Kassiano W et.al, 2023	Yes	1	0	1	0	0	1	1	1	1	1	7
Pedrosa GF et.al, 2022	Yes	1	0	1	0	0	1	1	1	1	1	7
Wolf M et.al, 2025	Yes	1	1	1	0	0	0	1	1	1	1	7
Krzysztofik M et.al, 2021	Yes	1	0	1	0	0	0	1	1	1	1	6

FINDINGS AND DISCUSSION

Overall, the studies reviewed consistently highlight the critical role of muscle length and joint position in maximizing hypertrophy, strength, and neuromuscular adaptations. Training muscles such as the rectus femoris at longer muscle lengths produces superior hypertrophy and strength gains compared to shorter lengths or full range of motion (ROM), particularly in lower limb exercises. While vastus lateralis shows no significant difference between full and partial ROM, partial ROM at longer muscle lengths often enhances hypertrophy more effectively. Specific joint angles, like extended elbow positions and overhead arm placements during triceps extension, increase mechanical tension and muscle stretching, leading to greater strength and muscle growth. Biomechanical at longer nger muscle lengths include increased fascicle length, lower pennation angle, greater tendon stiffness, and hypertrophy concentrated in distal muscle regions. Neuromuscular efficiency also improves, as seen with dorsiflexion enhancing motor unit discharge rates and torque production compared to plantar flexion.

Muscle growth patterns differ depending on exercise type and muscle length, with eccentric exercises and stretching promoting longitudinal hypertrophy, while concentric and isometric contractions mainly increase cross-sectional area. Partial range of motion exercises induce greater hypoxia, resulting in superior hypertrophy and isometric strength gains compared to full ROM, making them effective for overcoming plateaus in trained individuals. Training beyond failure at lengthened muscle positions further enhances hypertrophy but may increase discomfort, necessitating individualized programming. Overall, these findings the importance of emphasizing longer muscle lengths and specific joint angles, along with tailored training variables, to optimize muscle growth, strength, and neuromuscular performance in resistance training programs.

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Table 2 -Characteristics of the included studies

	Source title	Authors and publication year	Methods/Interventions	Major findings
1	The effects of hip flexion angle on quadriceps femoris muscle hypertrophy in the leg extension exercise	Stian Larsen et.al(2024)	22 participants allocated to the 40° or 90° degrees hip flexion angle position	Greater hypertrophy of the rectus femoris with 40 degrees of hip flexion compared to 90 degrees
2	Training in the initial range of motion promotes Greater muscle adaptation than at final in the arm curl	Gusatavo F Pedrosa et.al(2023)	Group 1 trained one arm in the initial ROM (0-68 degrees) and the other in the final ROM (68-135 degrees) for eight weeks	Training in the initial range of motion led to significant strength improvements and better neuromuscular adaptations
3	Which ROMs lead to Rome? A systematic review of the effects of range of motion on muscle hypertrophy	Witalo Kassiano et.al (2023)	Systematic review conducted for the articles comparing the effects of full ROM (fROM) and partial ROM (pROM) on muscle hypertrophy	Better muscle hypertrophy for biceps and triceps brachii, rectus femoris, vastus lateralis in longer muscle length training. Better muscle hypertrophy of glutes and hip adductors when trained in full ROM
4	The Influence of Hip and Knee Joint Angles on Quadriceps Muscle-Tendon Unit Properties during Maximal Voluntary Isometric Contraction	Alessandra Martins Melo de Sousa, et.al (2023)	Randomized, single-blinded, repeated-measures study. 20 healthy young men performed maximal isometric quadriceps contractions in four hip and knee angle positions, measuring torque, EMG, muscle architecture, and tendon properties.	Knee flexion at 60° (vs. 20°), regardless of hip angle, resulted in higher peak torque, neuromuscular efficiency, fascicle length, and tendon stiffness.
5	Regional Hypertrophy: The Effect of Exercises at Long and Short Muscle Lengths in Recreationally Trained Women	Aitor Zabaleta-Korta, et al (2023)	Thirty-one Participants in the study were divided into two groups: INC group: Performed inclined bicep curls, PREA group: Performed preacher curls	The distal region of the arm showed significant growth in the preacher curl group, compared to Inclined curls group .
6	Differential changes in muscle architecture and neuromuscular fatigability induced by isometric resistance training at short and long muscle-tendon unit lengths	Ryota Akagi et.al (2020)	13 recreationally active individuals (7 males, 6 females) isometric training for the tibialis anterior at either short or long muscle-tendon unit lengths.	Training at long muscle lengths increased fascicle length, short-length training increased pennation angle without affecting fascicle length.
7	Does longer-muscle length resistance training cause greater longitudinal growth in Humans? A systematic review.	Milo Wolf, et.al (2025)	systematic review conducted following PRISMA guidelines. three databases were searched for studies comparing longer- versus shorter-muscle length resistance training in healthy adults.	Better muscle size and fascicle length increase with longer muscle length resistance training than shorter muscle length training
8	Stimuli for adaptation in muscle length and the length range of active force exertion- A narrative review	Annika Kruse ,et al (2021)	narrative review summarizing existing literature on: - Current knowledge gaps regarding longitudinal muscle growth regulation. - Potential strategies for	Active or passive mechanical loading at long muscle lengths is likely to promote longitudinal growth. Stretching with Activation: Combining stretching with activation (e.g., static stretching with

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			inducing longitudinal muscle growth	electrical stimulation) appears promising for inducing longitudinal muscle growth.
9	Partial ROM exercise is effective for facilitating muscle hypertrophy and functions through sustained intramuscular hypoxia in young, trained men.	MASAHIRO GOTO, et al (2019)	41 young, trained men randomly allocated to train at different elbow joint ROMs (PRE: 45-90 degrees, FRE: 0-120 degrees).	Greater muscle growth and strength gains in partial ROM exercise than full ROM exercise.
10	Placing Greater Torque at Shorter or Longer Muscle Lengths? Effects of Cable vs. Barbell Preacher Curl Training on Muscular Strength and Hypertrophy In Young Adults	João Pedro Nunes , et al(2020)	35 participants randomly assigned to cable curls or preacher curls group.	Barbell group showed greater strength gains at longer muscle length than cable group.
11	Resistance training beyond momentary failure: the effects of past-failure partials on muscle hypertrophy in the gastrocnemius	Stian Larsen et.al (2025)	23 untrained men performed unilateral standing Smith machine calf raises. one limb trained in plantar flexion and the other limb trained in dorsiflexion.	Slightly better medial gastrocnemius muscle thickness in dorsiflexion group.
12	Can muscle fatigue in women be influenced by knee extension tasks in different ranges of motion?	GUSTAVO FERREIRA PEDROSA et al (2022)	Nine untrained women performed 1RM knee extension tests and submaximal dynamic exercise in three different ranges of motion (INITIALROM, FINALROM, FULLROM), with pre- and post-exercise torque measured at 30° and 100° of knee flexion.	A greater torque reduction occurred at 30° of knee flexion than at 100°
13	Partial Range of Motion Resistance Training: A Feasible Bodybuilding Training Regiment for Local or Regional Muscle Hypertrophy?	Daniel E. Newmire, et al (2020)	The article reviewed existing literature and research related to pROM resistance training and its potential benefits for bodybuilders, physique competitors etc	The pROM resistance training may have benefits for local or regional muscular hypertrophy.
14	Muscle Hypertrophy Response to Range of Motion in Strength Training: A Novel Approach to Understanding the Findings	Charlie R. Ottinger, et al (2022)	Review analyzing studies on how range of motion (ROM)inn resistance training affects muscle hypertrophy, focusing on each muscle's length tension curve.	The muscles active on the descending limb of the length-tension curve tend to exhibit greater hypertrophy with larger ROMs.
15	Partial vs Full Range of Motion Resistance Training: A Systematic Review and Meta-Analysis	Milo Wolf, et.al (2023)	Systematic Review and Meta-Analysis: Conducted in accordance with PRISMA guidelines. - Studies included - resistance training interventions comparing fROM and pROM across various outcomes.	Full ROM slightly outperforms partial ROM. Partial ROM at long muscle lengths may boost muscle growth.
16	Effect of ankle joint position on triceps surae contractile properties and motor unit discharge rates	Kalter Hali et.al (2020)	10 Participants performed isometric plantar flexion contractions at two ankle joint positions (20°	lower strength and torque generation in plantar flexion, higher motor unit discharge rates in dorsiflexion position.

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			dorsiflexion and 20° plantar flexion).	
17	Elbow Joint Angles in Elbow Flexor Unilateral Resistance Exercise Training Determine Its Effects on Muscle Strength and Thickness of Trained and Non-trained Arms	Shigeru Sato et.al (2021)	32 untrained young adults randomly assigned to three groups: extended joint training (EXT, 0°–50°), flexed joint training (FLE, 80°–130°), and a non-training control group.	Significant increases in MVC-ISO torque, MVC-CON torque, MVC-ECC torque, muscle thickness in the trained arm for EXT group Better cross education effect seen in EXT group.
18	Triceps brachii hypertrophy is substantially greater after elbow extension training performed in the overhead versus neutral arm position	Sumiaki Maeo a et.al (2023)	21 participants training unilateral elbow extension training with one arm in the overhead position (Overhead-Arm) and the other arm in the neutral position (Neutral-Arm)	Greater Triceps brachii hypertrophy in overhead triceps extension group than neutral Arm triceps extension group
19	Optimizing Resistance Training Technique to Maximize Muscle Hypertrophy: A Narrative Review	Patroklos Androulakis Korakakis et.al (2023)	Narrative review of existing literature on resistance training variables and their impact on muscle hypertrophy.	1. Significant hypertrophy with repetition duration between 2 and 8 seconds. 2. Training at long muscle lengths may elicit more distal hypertrophy.
20	Fatigue and Metabolic Responses during Repeated Sets of Bench Press Exercise to Exhaustion At Different Ranges of Motion.	Athanasios Tsoukos et al. (2024)	Ten resistance-trained men performed three sets of bench press to momentary failure in 3 different ROMs-full ROM (FULL), bottom half (BOTTOM), and top half (TOP).	TOP ROM allowed for lifting a higher load and performing more repetitions Fatigue was higher in BOTTOM than TOP.
21	Partial versus full range of motion triceps Strength training on shooting accuracy Among recreational basketball players: A randomized controlled trial	Imtiyaz Ali Mir, et al (2025)	30 recreational basketball players were randomly assigned to three groups: FROM group, PROM group, and control group (CON).	PROM training was more effective than FROM and CON groups in improving shooting accuracy.
22	Effect of Large Versus Small Range of Motion in the Various Intensities of Eccentric Exercise-Induced Muscle Pain and Strength	CHAKRAVARTHY M SADACHARAN and SUMIN SEO (2021)	34 untrained men participated in Eccentric exercises with PROM (60° of total ROM) and FROM, using 15%, 25%, and 35% of maximal voluntary isometric contraction (MVIC) over eight weeks.	Eccentric exercises with FROM induced greater DOMS, pain, and functional limitations compared to PROM. -Muscle strength increased more with FROM than PROM.
23	Greater Gastrocnemius Muscle Hypertrophy After Partial Range of Motion Training Performed at Long Muscle Length	Witalo Kassiano et al (2023)	Forty-two healthy adult women aged 18–35 years were randomly assigned to one of three groups: FULLROM, INITIALROM,FINALROM	greater increases in medial gastrocnemius and lateral gastrocnemius thickness in INITIAL ROM group, compared to FULLROM and FINAL ROM.
24	Greater Hamstrings Muscle Hypertrophy but Similar Damage Protection after Training at Long versus Short Muscle Lengths	Sumiaki Maeo, et al (2021)	Twenty healthy adults performed unilateral seated leg curl training with one leg and prone leg curl training with the other leg for 12 weeks.	Greater hamstrings muscle hypertrophy in Seated leg curl group than prone leg curl group
25	Partial range of motion training elicits favorable improvements in muscular Adaptations when carried out at long muscle lengths	Gustavo F. Pedrosa, et al (2022)	knee extension exercises in different ROM configurations (Full ROM, Initial Partial ROM, Final	The INITIALROM group showed a greater relative increase in muscle hypertrophy at 70% and, at

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			Partial ROM, Varied ROM) for 12 weeks.	50% and 60% muscle length
26	Lengthened partial repetitions elicit similar muscular adaptations as full range of motion repetitions during resistance training in trained individuals	Milo Wolf et al,(2025)	Every individual randomly assigned to either Lengthened partials (LP) group or full ROM group	Similar improvements in muscle thickness and muscle strength in LP group and Full ROM group
27	Appropriate Reporting of Exercise Variables in Resistance Training Protocols: Much more than Load and Number of Repetitions	Giuseppe Coratella (2022)	The author conducts a conceptual review, synthesizing existing literature to explore exercise variables that influence strength, hypertrophy, and muscle architecture.	Many within-exercise variables, including performing repetitions to failure/not load displacement/range of motion, time under tension and performing concentric- or eccentric-only or concentric–eccentric phase, and inter-set rest, may affect resistance training-induced adaptations in strength or muscle structure.
28	Range of motion of resistance exercise affects the number of performed repetitions but not a time under tension	Michał Krzysztofik, et al (2021)	Eighteen resistance-trained men performed 3 sets to muscular failure of bench press exercise with the cambered or standard barbell at 50% of one-repetition maximum (1RM).	Lower repetitions in cambered barbell, but a greater number of repetitions during the standard barbell bench press.
29	Effect of muscle length on maximum evoked torque, discomfort, contraction fatigue, and strength adaptations during electrical stimulation in adult populations: A systematic review	Jonathan Galvão et al (2024)	Systematic review of electronic databases (PUBMED, Web of Science, EMBASE, PEDro, BIREME, SCIELO, and Cochrane) from June 2022 to October 2023.	greater torque at optimal muscle length, during nerve stimulation. Greater strength gains for protocol at the optimal muscle length than for short muscle length

CONCLUSION

The data collected through this research, emphasizes the importance of muscle length and joint position in resistance training outcomes. Training at longer muscle lengths consistently demonstrated superior results in muscle hypertrophy, torque generation, and neuromuscular efficiency compared to full range of motion (ROM) exercises. These findings imply that resistance training protocols should prioritize exercises at longer muscle lengths to optimize hypertrophy, strength, and neuromuscular adaptations. While partial ROM training shows promise, further research is needed to explore its mechanism and the limitations mentioned above. Additionally, individualized approaches are recommended to balance discomfort with effective adaptation strategies.

Overall, the descriptive analysis of these studies showed an equal or better outcomes towards longer muscle exercises than full ROM exercises. However, our study also comes with some limitations as mentioned – Very few articles were found related to partial ROM exercises in cable machines, lacking evidence for effects partial ROM training in cable machines. Majority of the articles focused on the effects partial ROM training in the upper limb and lower limb muscles, but no articles were found related to the effects of partial ROM training in trunk musculatures. Majority of the articles focused on the effects of partial ROM training in non-trained individuals, whereas the effects of pROM training is unclear in trained individuals. Further research is suggested to explore the effects of longer muscle length training in older individuals, as majority of the studies included only adult participants in the study. Further research is suggested to provide a clear explanation on the mechanism of greater muscle hypertrophy in longer muscle length training. The findings may be useful for the practitioners and for medical tourism [31,32].

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ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

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EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

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