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Effects of Strength Training on Neuromuscular Adaptations in the Development of Maximal Strength: A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

Support - Kim Geok Soh.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 9 November 2024 and was last updated on 9 November 2024.

INTRODUCTION

Review question / Objective Strength training is an effective exercise intervention widely used in athletes' training and promoting health among the general population. The primary objective of strength training is to enhance maximum muscle strength and functional performance through a systematic approach. Recently, many studies have examined the effects of strength training on neuromuscular adaptations in developing maximum muscle strength, revealing the physiological mechanisms that enhance muscle strength. These mechanisms include structural changes in muscle fibres and adaptive responses in the nervous system. Neuromuscular adaptation refers to the physiological changes due to the interaction between the nervous and muscular systems during strength training. Strength training can remodel the nervous and muscular systems, allowing muscles to exert strength more effectively under high-intensity loads [1][2]. However, current research indicates variability in training methods, models, and subjects regarding maximum strength development. Some studies suggest that different muscle contraction forms correlate with motor unit activation patterns [3]. These factors may result in variations in training outcomes observed in muscles during exercise [4][5]. However, the specific mechanisms by which strength training induces neuromuscular adaptations for maximum strength and the dose-response relationships that contribute to these adaptations remain poorly understood. Therefore, a systematic meta-analysis that integrates existing literature will comprehensively understand how strength training influences neuromuscular adaptations and the associated dose-response relationships, addressing current research gaps. Research on neuromuscular adaptations related to developing maximum strength through strength training has significant theoretical and practical implications, offering valuable scientific guidance and a foundation for future research and practical applications.

Condition being studied This study provides a systematic review of neurological and muscular adaptation and maximal strength-related motor performance in healthy adult subjects following strength training.

METHODS

Search strategy Chinese search terms: "Resistance Training" "Strength Training" "Resistance Exercise" "Weight Training" "Neuromuscular Adaptation" "Neural Adaptation" "Muscular Adaptation"; English search terms: "Strength training" "strength" "resistance training" "strengthening programs" OR "progressive strength training" "resistance exercise" "weight lifting" "weight exercise" "strength exercise" "weight training" "intensive strength training" "Neuroadaptation" "Neuromuscular adaptations" "neuromuscular function" "muscle adaptation".

Participant or population To receive the intervention, the population must be healthy adults with no history of injury or fracture disease, have not been in the last 3 months, and have not taken any exercise supplements during strength training.

Intervention The intervention was strength training alone.

Comparator The control group could be trained for strength training or daily activities.

Study designs to be included Subjects were healthy adults; The intervention was pure strength training; Results included outcome measures related to neuromuscular adaptation and improved maximal strength.

Eligibility criteria ①Studies must employ a randomised controlled design. The research subjects and methods must clearly define the experimental, control, and comparison groups, ensuring uniform distribution of samples by age, gender, etc., with random and parallel interventions. ②Study subjects should include three populations: well-trained competitive athletes, fitness enthusiasts with general training experience, and healthy adults without training experience. ③The study design must involve pure resistance training, with detailed descriptions of training type, load volume, intensity, frequency, and cycle. ④The results section must include detailed data analysis tables showing pre- and post-training changes in physiological and biochemical indicators between experimental and control groups, along with statistical tests.

1.2.2 Exclusion criteria
①The literature lacks detailed experimental procedures, data, or result analysis. ②The study subjects are animals or patients. ③The experimental design employs non-resistance training methods. ④The documents include conference papers, review articles or duplicates. ⑤The literature does not explicitly address neuromuscular adaptations related to maximal strength.

Information sources 2000-01-01/2024-9-02. Form China National Knowledge Infrastructure, Wanfang Database, PubMed, Web of Science, SCOUPS, EBSCOhost (SPORT Discus) database.

Main outcome(s) Outcome measures included measures of maximum strength in the upper or lower limbs, neurological adaptations such as EMG, and muscle adaptations such as percentage of muscle fibers, and muscle cross-sectional area.

Quality assessment / Risk of bias analysis The assessment criteria comprise seven evaluation indicators: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other biases. The overall evaluation of the risk of bias in the included literature results in three judgment categories: low risk of bias (Grade A), unclear risk of bias (Grade B), and high risk of bias (Grade C). Study quality is classified into three levels based on the number of fulfilled evaluation criteria: Grade A for ≥4, Grade B for 2 to 3, and Grade C for ≤1. A total of 62 studies included 1,109 participants with varying physical activity levels. The methodological quality assessment is performed on the 23 included studies using the Cochrane risk of bias assessment tool.

Strategy of data synthesis Heterogeneity analysis was carried out by Review software, articles were screened and article information was processed by Endnote, and EGG values were calculated by statsmp18.

Subgroup analysis In the subgroup analysis, the maximum strength was divided into upper and lower limbs or the subjects had or did not have strength training experience, and the muscle thickness was divided into rectus femoris, biceps, pectoralis major muscle, etc.

Sensitivity analysis Sensitivity analysis, which was performed by review software, compared with the studies in the group that had a greater impact on heterogeneity outcomes.

Country(ies) involved Malaysia.

Keywords Resistance Training; Maximal Strength; Neural Adaptation; Muscle Adaptation.

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