Bulletin of the *Transilvania* University of Braşov
Series IX: Sciences of Human Kinetics • Vol. 17(66) No. 2 – 2024
https://doi.org/10.31926/but.shk.2024.17.66.2.9

MUSCULAR ENDURANCE TRAINING: BRIDGING GYM PRACTICES WITH SCIENCE RECOMMENDATIONS

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Abstract: *This study investigated the effectiveness of training methodologies for improving muscular endurance in young adult males and whether these practices align with scientific recommendations. A cross-sectional descriptive comparative study was conducted with 115 male participants aged 18 to 26. Data on various training parameters were collected using a self-administered questionnaire. The results indicated that participants exhibited discrepancies in their training practices compared to established scientific recommendations. An important percentage of study participants did not exercise according to the recommended guidelines regarding exercise sequencing, intensity, repetitions, rest periods, and training supervision. Participants who followed the recommendations regarding intensity, sets, repetitions, weekly training frequency, and supervision achieved higher objective accomplishment scores. Thus, there are notable discrepancies between everyday gym practices and scientific recommendations for improving muscular endurance in young adult men. Adherence to current recommendations and professional supervision are essential for maximizing training effectiveness, preventing injuries, and facilitating future adaptations.*

Key words: *Muscular endurance, gym practices, strength and conditioning recommendations*

1. Introduction

Muscular endurance, defined as the ability of a muscle or muscle group to perform repeated contractions against a load for an extended period, is crucial for both athletic performance and everyday functional fitness [7]. The primary objective of muscular endurance training methods is to enable individuals to execute all actions demanded by their respective daily or sports activities with optimal intensity and efficiency, sustaining the optimal application of force throughout the activity or competition [6]. Developing muscular endurance becomes crucial to ensure athletes can uphold performance levels throughout a match or event, which is vital for success in competitive scenarios.

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Beyond the sports context, muscular endurance training offers multifaceted benefits. It contributes to maintaining good posture and stability over prolonged periods, enhancing overall functional fitness. The physiological adaptations associated with this form of training are diverse, including increased capillary density, mitochondrial biogenesis, improved oxygen utilization, and reduced lactic acid accumulation [6]. Additionally, the repetitive nature of endurance training strengthens connective tissues, such as tendons and ligaments, thereby contributing to the holistic health of joints [9], [12]. To ensure the attainment of these adaptations and improvements, it is necessary to exercise according to the training parameters established in the scientific literature to develop muscular endurance. Various recent publications indicate the conditions under which strength should be developed, depending on aspects such as age group, fitness level, or type of strength [5], [13].

As the number of people going to gyms has been increasing in recent years [6], each of whom follows different training methodologies, it becomes necessary to examine the effectiveness of these approaches compared with the recommendations described in contemporary literature. However, the dissemination of scientific knowledge is not considered essential in the field of sports sciences, as some authors have pointed out, due to various barriers such as lack of motivation of some coaches to acquire new knowledge, limited time availability, the use of jargon that complicates access for coaches and trainers, and the lack of collaboration between academic and sports institutions [2].

Nevertheless, if strength training is not performed in accordance with scientifically established guidelines, without the guidance of qualified professionals, and without tailoring the workloads to the individual's characteristics, or if strength training exercises are performed incorrectly from a biomechanical perspective, the risk of injury significantly increases [4], [13]. Therefore, this study aimed to scrutinize the effectiveness of the training methodologies employed for developing muscular endurance by young male adults, verifying whether everyday practices in gyms and fitness centres align with the recommendations established in the scientific literature.

2. Methods

The present cross-sectional descriptive comparative study comprised a cohort of 115 males (age: 21.39 ± 3.32; body mass: 84.1± 16.71; height: 176 ± 9.6, and BMI 27.2 ± 6.8). The inclusion criteria were: males aged 18 to 26 who had been engaged in continuous strength training for over three months but less than one year, were free from injuries or medical conditions hindering strength training, and conducted their training in fitness clubs or sports centres.

Data collection was conducted using a self-administered questionnaire consisting of a combination of open-ended and closed-ended questions. The questionnaire included 13 items: 1. Age; 2. Weight; 3. Height; 4. Selection of exercises; 5. Exercise sequencing; 6. Intensity; 7. Sets; 8. Repetitions; 9. Rest intervals; 10. Speed; 11. Weekly training frequency; 12. Training supervision; 13. Accomplishment of training objectives.

The preparation of the questionnaire involved creating each item in a clear and precise manner to ensure ease of comprehension by the study participants. For assessing the level of compliance with objectives, which is a non-quantitative variable, a scale ranging from 1 to 5 was utilized, where 1 indicated total non-compliance, and 5 signified total compliance. Before its implementation, the questionnaire underwent a rigorous validation process to ascertain its validity and reliability. The primary researchers collaborated to develop and evaluate the items slated for inclusion in the questionnaire, assigning ratings on a scale of 0 to 10. Only items with a score exceeding 8.00 were retained for inclusion in the questionnaire. The questionnaire's reliability was assessed with Cronbach's alpha, yielding a value of 0.91, indicating excellent internal consistency.

The data for this study was gathered in Saudi Arabia between May 15 and November 30, 2022, ensuring representation from the major fitness centers in the city. Data collection was conducted by the study's principal researchers, both experts in strength and conditioning training, utilizing digital tools via Excel sheets. After collecting data, the principal researchers thoroughly reviewed its completeness and accuracy before starting statistical analysis.

The statistical analysis was performed using SPSS software, version 26 (Chicago, IL, USA). Data normality was assessed with the Kolmogorov-Smirnov test, and homogeneity was tested with Levene's test. Comparisons between two conditions or cohorts were conducted using the independent samples t-test. One-way ANOVA with Tukey's post hoc test was employed for comparisons involving more than two cohorts or conditions. The effect size was estimated using the eat square η^2 parameter and interpreted as follows: 0.2 small, 0.5 moderate, and 0.8 large. The significance level was set at $p < 0.05$.

3. Results

The training parameters used by the study participants are depicted in Table 1.

Table 1

Recommendations established by the American College of Sports Medicine (2009) and Kraemer & Ratamess (2004) for improving muscular endurance, compared [1], [8] to study participants' training practices

	Muscular endurance recommendations	**Practices of the study participants**
Type of contraction	Eccentric and Concentric	Eccentric and Concentric: 100%; n=115
		Eccentric only:
		Concentric only:
Exercise selection	Multiple- and single-joint exercises	Multiple- and single-joint exercises: 52.17%; n=60
		Multiple-joint exercises only: 30.43%; n=35
		Single-joint exercises only: 17.39%; n=20
Sequencing	Various sequencing combinations for novice	Higher-intensity before lower-intensity exercises: 0%; n=0
		Opposing exercises: 17.39%; n=20
		Rotation of upper and lower body exercises: 30.43%; n=35
		Large muscle group before small muscle group exercises: 52.17%; n=60
		Multiple-joint before single-joint exercises: 0%; n=0

	Muscular endurance recommendations	Practices of the study participants
Intensity	50-70% of 1RM	<50%: 4.34%; n=5
		50-70%: 78.26%; n=90
		>70%: 17.39%; n=20
Sets	1-3	1-3: n=50; 43.47%; >3: n=65; 56.52%
Repetitions	10-15 repetitions	<10: 29.56%; n=34
		10-15: 57.39%; n=66
		>15: 13.04%, n=15
Rest between sets	<1 minute	<1 minute: 13.04%; n=15
		≥1 minute: 86.95%; n=100
Velocity	Slow when performing between 10 and 15 repetitions, and moderate to fast when per-forming 15 to 25 repetitions	Slow: 8.69%; n=10
		Moderate: 91.31%; n=105
Weekly training frequency	2-3 day per week	2-3 days per week: 47.82%; n=55
		≥4 days per week: 52.17%; n=60
Training program supervision	Training must be supervised	Not supervised: 26.08%; n=30
		Supervised occasionally: 39.13%; n=45
		Always supervised: 34.78; n=40

The outcomes are juxtaposed with the recommendations outlined by the American College of Sports Medicine (2009) and Kraemer and Ratamess (2004) for muscular endurance training across the analyzed parameters [1], [8].

All study participants engaged in both concentric and eccentric contractions. Among them, 52.17% reported incorporating multiple- and single-joint exercises into their training regimen, while 30.43% exclusively focused on multiple-joint exercises and 17.39% solely performed single-joint exercises. Regarding exercise sequencing within sessions, 52.17% prioritized large muscle group exercises before targeting smaller muscle groups, 30.43% alternated between upper and lower body exercises, and 17.39% integrated stimulation of agonist and antagonist muscles. None of the participants conducted higher-intensity exercises before lower-intensity ones or multi-joint exercises before single-joint exercises.

Regarding training intensities, 4.34% utilized less than 50% of their one-repetition maximum (1RM), 78.26% exercised within the 50-70% of 1RM range, and 17.39% exceeded 70% of 1RM. Regarding the number of sets per exercise, 43.47% performed between one and three series, while 56.52% completed more than four or more four sets. Repetition ranges varied, with 29.56% performing fewer than 10 repetitions per set, 57.39% completing between 10 and 15 repetitions, and 13.04% doing more than 15 repetitions. Rest periods between sets were varied, with 13.04% resting for less than a minute, while 86.95% rested for a minute or longer. The majority (91.31%) executed strength exercises at a moderate velocity, with only 8.69% choosing a slower pace. In terms of training frequency, 47.82% trained two or three days per week, while 52.17% trained four or more times per week. Supervision during workouts varied, with 26.08% exercising without supervision, 39.13% occasionally supervised, and 34.78% always supervised. Furthermore, 56.52% of the participants indicated complete achievement of their objectives through training, while 43.46% reported partial achievement.

Additionally, study participants were divided into subgroups based on the selections made when applying each training parameter. Subsequently, the objective accomplishment level (OA) of each subgroup was compared (Table 2).

Table 2

Degree of achievement of the study participants' objectives based on their selections for each training parameter

	Muscular recommendations by the ACSM	Practices of the study participants
Type of contraction	Eccentric and Concentric	Eccentric and Concentric: 100%; n=115
		Eccentric only:
		Concentric only:
Exercise selection	Multiple- and single-joint exercises	Multiple- and single-joint exercises: 52.17%; n=60
		Multiple-joint exercises only: 30.43%; n=35
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Sequencing	Various sequencing combinations for novice	Higher-intensity before lower-intensity exercises: 0%; n=0
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Intensity	50-70% of 1RM	<50%: 4.34%; n=5
		50-70%: 78.26%; n=90
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Velocity	Slow when performing between 10 and 15 repetitions, and moderate to fast when performing 15 to 25 repetitions	Slow: 8.69%; n=10
		Moderate: 91.31%; n=105
Weekly training frequency	2-3 day per week	2-3 days per week: 47.82%; n=55
		≥4 days per week: 52.17%; n=60

	Muscular recommendations by the ACSM	Practices of the study participants
Training program supervision	Training must be supervised	Not supervised: 26.08%; n=30
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		Always supervised: 34.78; n=40

The ANOVA indicated the presence of a main effect for the parameters of sequence ($p = 0.004$, $\eta2 = 0.092$), intensity ($p < 0.001$, $\eta2 = 0.16$), repetitions ($p = 0.032$, $\eta2 = 0.11$), and training supervision ($p < 0.001$, $\eta2 = 0.45$). Tukey's subsequent analysis revealed that the OA of the study participants who first stimulated the large muscle groups before the small muscle groups during their training sessions was significantly higher than that of the subjects who alternated exercises between the upper and lower body ($p < 0.013$). Furthermore, the OA of the latter group was significantly higher than that of the subjects who performed opposing exercises ($p < 0.001$). The OA of subjects who used a training intensity between 50-70% of their one-repetition maximum (1RM) was significantly higher than those using an intensity higher than 70% of 1RM ($p < 0.001$), and the OA of the latter was in turn significantly higher than that of those who exercised with intensities less than 50% of 1RM ($p < 0.05$). Similarly, the OA of the subjects whose training was supervised was higher than that of those whose training was only occasionally supervised ($p < 0.001$), and the OA of the latter was higher than that of the study participants whose training was never supervised ($p < 0.001$). No significant differences in OA were observed between subjects who trained using multiple-joint exercises and those who used only single-joint exercises or between those who used only multiple-joint exercises and those who used only single-joint exercises.

The independent samples t-test revealed that the OA of the subjects who performed between one and three sets per exercise was higher than that of the subjects who performed four or more sets ($p = 0.002$; $\eta2 = 0.31$). The OA of subjects who rested one minute or more was higher than that of subjects who rested less than one minute ($p = 0.007$; $\eta2 = 0.29$). The OA of the subjects who performed their exercises at a moderate speed was higher than those who used a slow velocity ($p < 0.001$; $\eta2 = 0.49$). Additionally, the OA of subjects who trained between two and three times per week was higher than those who trained four or more times per week ($p < 0.001$; $\eta2 = 0.48$).

4. Discussion

One major finding is that while participants used concentric and eccentric muscle contractions, they did not employ two recommended exercise sequencing methods: performing multiple-joint exercises before single-joint exercises and starting with higher-intensity exercises before the lower-intensity ones. Additionally, over 20% of subjects used inappropriate training intensities, more than 40% used a repetition range that did not align with recommendations, nearly half did not adhere to recommended exercise selections, over half did not follow the guidelines regarding the number of sets per exercise and the weekly training frequency. Less than 35% had their training sessions regularly supervised by expert coaches, and in about 90% of cases, subjects did not follow recommended rest periods between sets and exercise execution velocities.

The study participants who adhered to recommendations regarding intensity, sets, repetitions, weekly training frequency, and supervision of their training program achieved higher OA scores. Surprisingly, those who did not follow the current recommendations regarding rest between sets and exercise velocity obtained higher OA scores. This could be attributed to the fact that a more than one-minute rest time between sets allows for better recovery, enabling participants to maintain appropriate intensity throughout all sets despite fatigue. As for the speed of exercise execution, the better results obtained by those using moderate speeds compared to those using slow speeds may be because when completing 15 or more repetitions is more effective to use moderate speeds — as suggested by Kraemer & Ratamess [8]—, and many subjects who performed the correct number of repetitions were closer to 15 than 10.

In any case, subjects must adhere to the established recommendations to enhance effectiveness and safety. This enables them to achieve their goals while preventing injuries and emotional issues resulting from load assimilation difficulties and limiting their reserve of adaptation. Concerning the sequencing of exercises within the training session, subjects must utilize all five available methods, rather than just one, to introduce greater variability into their training [8]. The same applies to exercise selection. Utilizing multi- and single-joint exercises offers advantages over relying solely on one type of exercise. Single-joint exercises are suitable for beginners due to their lower technical and coordinative demands, as they target specific muscle groups [3]. However, multi-joint exercises are also beneficial as they mimic daily tasks and sport-specific movements, induce greater metabolic stress, enhance muscle activation, and improve overall performance [3]. Concerning weekly training frequency, intensity, number of sets, and repetitions, surpassing the recommended training Volume and intensity can lead to injuries and difficulties in emotional assimilation and may hinder the possibility of achieving future training adaptations [11]. On the contrary, utilizing a Volume and intensity lower than the recommended may hinder the achievement of planned adaptations in the training process because the training stimulus falls below the required threshold of stimulation [11]. Finally, training sessions must be supervised to ensure their effectiveness and safety, as demonstrated by Roos et al. (2015) [10], who observed improved training of trainers correlates with greater improvements.

5. Conclusion

There are discrepancies between everyday practices in gyms and fitness centers and the established scientific recommendations for improving muscular endurance in young adult men. Many participants do not follow recommended guidelines regarding exercise sequence, intensity, repetitions, rest between sets, and training supervision. Those who adhered to scientific recommendations achieved better results in terms of training goals. When developing muscular endurance, following the current strength and conditioning recommendations and having the training sessions planned and supervised by professionals to maximize effectiveness, prevent injuries, and facilitate future adaptations is essential.

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