
THE COMBINED ACUTE EFFECTS OF MASSAGE, REST PERIODS, AND BODY PART ELEVATION ON RESISTANCE EXERCISE PERFORMANCE

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ABSTRACT

Although massage administered between workouts has been suggested to improve recovery and subsequent performance, its application between bouts of repetitive supramaximal anaerobic efforts within a given workout has received little attention. The purpose of the study compared different forms of very short rest periods administered between resistance exercise sets of individual workouts on subsequent performance. With a within-subjects design methodology, subjects ($n = 30$) performed three workouts that were identical in terms of the exercises (45° leg press, prone leg curl, seated shoulder press, standing barbell curl), number of sets, and the resistance employed. For each workout, subjects received one of the following treatments between sets: 1 minute of rest as they stood upright, 30 seconds of rest as they stood upright, or 30 seconds of concurrent massage and body part elevation (MBPE), which entailed petrassage of the exercised limbs in a raised and supported position in an attempt to abate fatigue and enhance recovery from the previous set. Subjects were instructed to perform as many repetitions as possible for each set. For each exercise, two dependent variables were calculated: a total work/elapsed time ratio and the cumulative number of repetitions performed. For each exercise, one-way repeated-measures analysis of variance and Tukey's post hoc test revealed the following total work/elapsed time results: 1 minute rest <30 seconds' rest, 30 seconds' MBPE. For each exercise, cumulative repetition results were as follows: 1 minute rest >30 seconds' rest, 30 seconds' MBPE. Results imply that rest period duration exerts more influence on resistance exercise performance than MBPE. Those who seek improved resistance exercise performance should pay particular attention to rest period durations.

KEY WORDS anaerobic, weight training, recovery

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INTRODUCTION

Resistance exercise is an integral part of training programs that may lead to large performance improvements. Athletes and those interested in greater exercise performance are in a constant search for ways to enhance their workouts. This has led some to seek out acute anecdotal treatments that are simple to apply and may yield immediate benefits. Massage is a treatment that has been touted to improve resistance exercise and athletic performance via a hastened recovery process. Whereas early Eastern European claims advanced the notion that massage aids performance via improved circulatory and lymphatic clearance (2,5,8,23), recent Western studies have questioned its efficacy (3,18,24). The equivocal physiological and performance outcomes from previous studies may, in part, result from the manner of massage administration.

Numerous studies have examined the chronic effects of massage applied between workouts on athletic performance (5,12,23,24). However, some endeavors are characterized by repetitive bouts of intense anaerobic activity interspersed with very short rest periods that evoke sharp declines in muscle pH and performance with subsequent exercise (7,10). One such activity is resistance exercise, during which repetitions are performed to a point of momentary muscular failure. Such bouts usually last 30–60 seconds as anaerobic glycolysis acts as the primary ATP resynthesis pathway. Glycogen breakdown and lactate formation rates increase exponentially in response to supramaximal exercise (7,10). Unlike traditional massage, which is given between workouts to hasten recovery and improve performance, the acute effects of massage applied between repetitive bouts of a single workout have received little attention (4).

A reputed benefit of massage is improved circulation, which may hasten exercise-induced metabolite transport to tissues (heart, liver, etc.) capable of oxidation (5,8). Given the abrupt change in muscle pH incurred from supramaximal exercise, perhaps an additional treatment concurrently administered with massage throughout resistance exercise rest periods may prove valuable. Whereas exercise-induced sympathetic stimulation improves venous tone and circulation, anatomical elevation of the involved muscle group may allow gravity to further aid recovery via hastened clearance

rates. Combined with massage, such a treatment reduces peripheral resistance to blood flow, which could hasten recovery and improve subsequent resistance exercise performance (1,22). To date, the combined acute effects of massage and body part elevation applied throughout rest periods are unknown.

As it relates to resistance exercise rest periods, their duration dictates subsequent performance and the type of adaptation incurred (19,20,25). Ideally, the duration of rest is commensurate with the training adaptation (strength, power, etc.) sought. Rest intervals in excess of the time required to evoke a given adaptation may adversely affect performance and the rate of improvement. Current study results, in which a multi-set protocol of traditional bodybuilding exercises was interspersed with very short rest periods, may be of most interest to those who seek greater muscle hypertrophy; as such, paradigms maximize endogenous growth hormone secretion (9,15,17,26). In the current study, we examined whether massage and body part elevation (MBPE) applied throughout rest periods improves subsequent resistance exercise performance under conditions associated with bodybuilding training. We also note the impact of rest period duration on subsequent performance. Results will elucidate the value of acute MBPE application and rest period duration on subsequent resistance exercise performance and whether such treatments benefit those who perform (bodybuilders) similar workout protocols. We hypothesize that one or more of the aforementioned treatments (massage and body part elevation, rest period duration) will exert a greater influence on performance.

METHODS

Experimental Approach to the Problem

To examine how massage, body part elevation, and rest periods affect resistance exercise performance, subjects performed three workouts as part of a within-subjects design. Subjects were experienced weight trainers whose first study workout was preceded by a session in which their one repetition maximum (1RM) values were assessed for the following exercises: seated 45° leg press, prone leg curl, seated shoulder press, and standing barbell curl. Workouts included all four exercises performed in the order listed. Rest period treatments between sets entailed either; 1) 1 minute of passive rest as subjects stood upright; 2) 30 seconds of passive rest as subjects stood upright; or 3) 30 seconds of rest with concurrent MBPE of the exercised muscle group. The type of rest period was held constant throughout a given workout. From the start to the completion of each exercise, which included rest periods, the elapsed time was recorded with a stopwatch.

Subjects

Thirty (27 men, 3 women) physically active subjects provided informed written consent to participate. Study procedures were approved by a university-based human subjects committee. All subjects were familiar with the study exercises and

averaged 3 years' experience with each lift. Their normal workouts typically lasted just less than 2 hours and entailed training of multiple body parts and exercises. General subject characteristics (mean \pm SEM) were collected for age (24.0 ± 0.8 years), height (175.3 ± 1.0 cm), and weight (78.3 ± 2.5 kg). All subjects were informed of the nature of the study and did not allow their sleeping, eating, and drinking habits to change throughout project participation.

Massage

Petrassage (vigorous repetitive kneading) to the prime movers of the leg press (knee extensors), leg curl (knee flexors), shoulder press (deltoid), and barbell curl (elbow flexors) was administered throughout rest periods of one of the three workouts. Petrassage was done with the exercised muscle group elevated anatomically so it lay superior to the thoracic and abdominal cavities, where oxidative tissues reside. To achieve such postures, subjects immediately lay supine between leg press and leg curl sets and propped their legs on a nearby object so that their hips were flexed 80° as they received petrassage. Between barbell curl sets performed within a power rack, subjects abducted their glenohumeral joints 100° relative to the anatomical position and braced their arms on nearby supports so that blood flowed downward as they received petrassage. Between shoulder press sets, subjects stayed seated as their arms hung relaxed and treatment was applied. Because of the body position for the shoulder press, in which the deltoids lie superior to the thoracic and abdominal cavities, no added effort was made to reposition the body. For massage-free workouts, subjects stood upright and did not lean against equipment during the allotted rest period duration.

How Each Exercise was Performed

The four current study exercises were chosen to represent a wide variety of movements used in bodybuilding workouts. They entailed two upper- and lower-body exercises, two "pushing" and "pulling" movements, and two single-joint and compound lifts. The current study utilized both isolation and machine-based exercises common to muscle hypertrophy protocols (26); thus, the exercises provided a broad representation of movements used in bodybuilding workouts.

The seated 45° leg press device included a padded chair on which subjects sat as the exercise was performed. Subjects placed their feet on a large footplate directly in front of them, which ran along an inclined 45° linear track. Weighted plates were added to either side of the footplate to increase resistance. After the footplate locking mechanism was disengaged, subjects flexed their knees and hips to slowly lower the footplate so that their knees flexed at least 100° from their fully extended position at the start of the exercise. Subjects then extended their knees and hips against resistance to raise the footplate and complete repetitions.

The knee flexors were exercised on a prone leg curl machine. A series of cable and pulleys attached a padded lever arm to a selectorized weight stack that offered resistance.

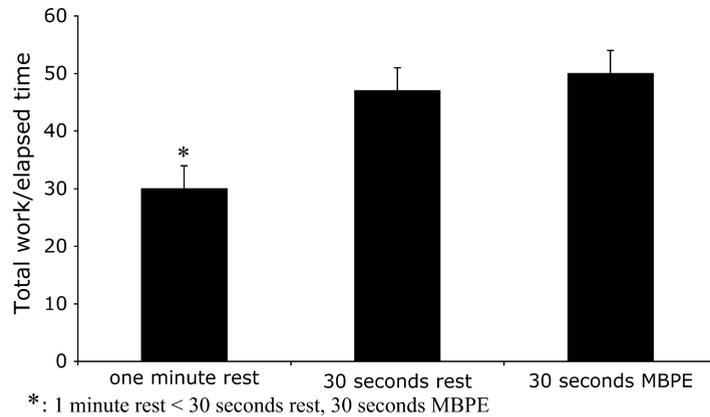


Figure 1. Leg press total work/elapsed time data (mean ± SEM) for each workout.

With their legs under the lever arm, subjects flexed their knees to overcome the resistance. From the start of repetitions, in which the knees were fully extended, subjects flexed their knees through 90° of motion before slowly lowering the padded arm to complete a repetition. Subjects were instructed to keep the hips and torso flat on the padded bench throughout leg curl repetitions.

For the shoulder press, subjects were seated upright on an exercise machine that included a padded chair with two shoulder-level handles located on each side of the body. As with the leg curl, shoulder press resistance was provided by a series of cables and pulleys that attached the handles to a selectorized weight stack. Subjects grabbed the handles and fully extended their elbows against the resistance so that their

arms were in an overhead position to complete repetitions. Throughout the exercise, subjects were instructed to keep their torso against the padded chair while in the seated position.

The barbell curl was performed with a supinated shoulder-width grip. From the start of repetitions with a barbell against the thighs, the elbow flexors exerted torque to curl the weight until it reached shoulder level. The elbow flexed approximately 130° as the barbell ascended with each repetition, then was slowly lowered to complete the effort. To eliminate the use of body momentum to complete repetitions, subjects performed the exercise with their lower backs against a second stationary barbell placed on a power rack. Hyperextension or back movement off the stationary barbell as subjects curled

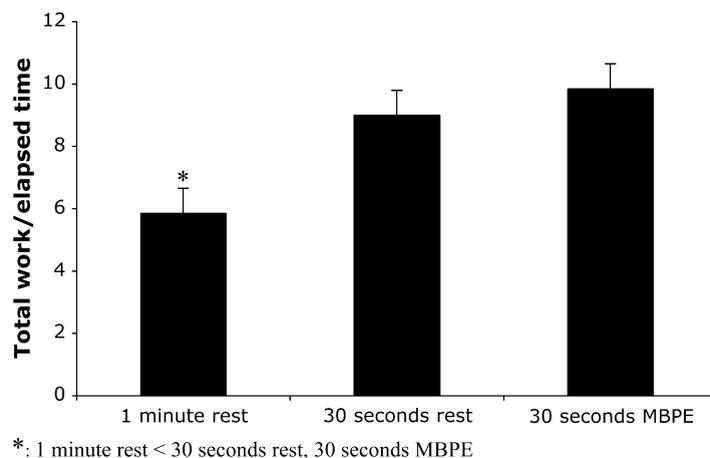


Figure 2. Leg curl total work/elapsed time data (mean ± SEM) for each workout.

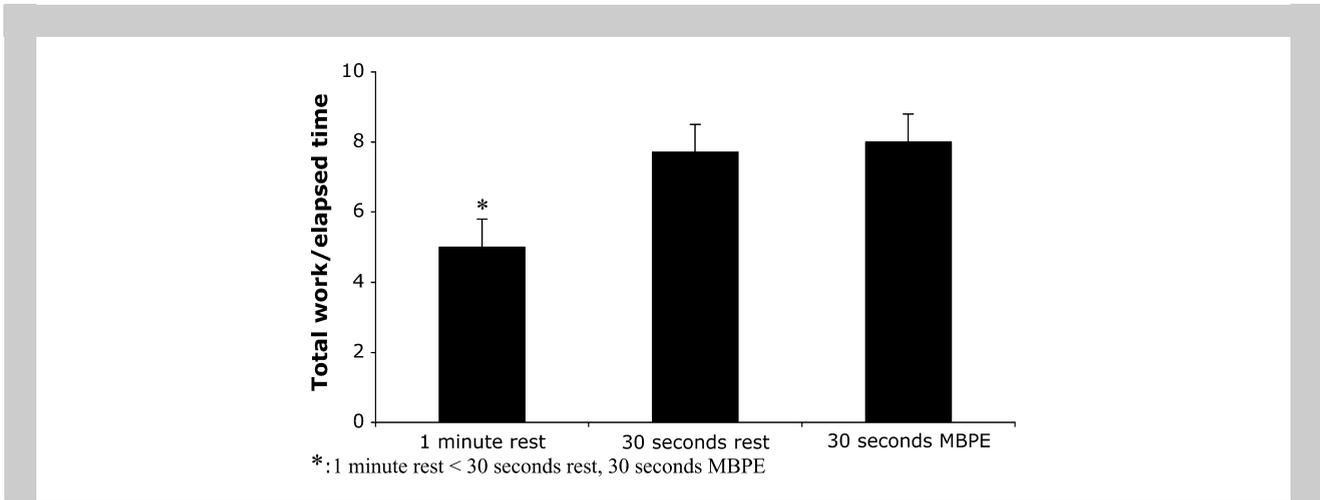


Figure 3. Shoulder press total work/elapsed time data (mean ± SEM) for each workout.

was deemed momentum and the set was immediately terminated. Proper exercise technique was monitored by the principal investigator to ensure that repetitions were performed correctly. Those that did not were excluded from statistical analysis.

Workout Protocol

The intent of the study’s workout protocol was for subjects to incur a substantial degree of fatigue and permit the merits of MBPE and rest period duration to be assessed. We therefore used a within-subjects design methodology in which subjects performed three workouts identical in terms of the exercises, number of sets, and the resistance employed per set. For each set, subjects were instructed to perform as many repetitions as possible. A single rest period treatment was applied during each workout; their sequence was

randomized to reduce the likelihood of an order effect. Workouts were spaced a week apart to reduce the impact of delayed onset muscle soreness on subsequent workouts. Each workout consisted of eight sets per exercise, which allowed multiple rest period treatment administrations with each exercise and offered a substantial opportunity to note workout performance differences among the three treatments. To reduce the risk of injury, subjects began each workout with a warm-up that entailed two sets of leg presses at 50% of the 1RM load and static stretching. The resistance used per exercise was as follows: first set: 70% of the 1RM load; second and third sets: 80% of the 1RM load; fourth and fifth sets: 90% of the 1RM load; sixth and seventh sets: 75% of the 1RM load; and eighth set: 65% of the 1RM load. Subjects were instructed not to pace themselves and received a 5-minute rest period between exercises.

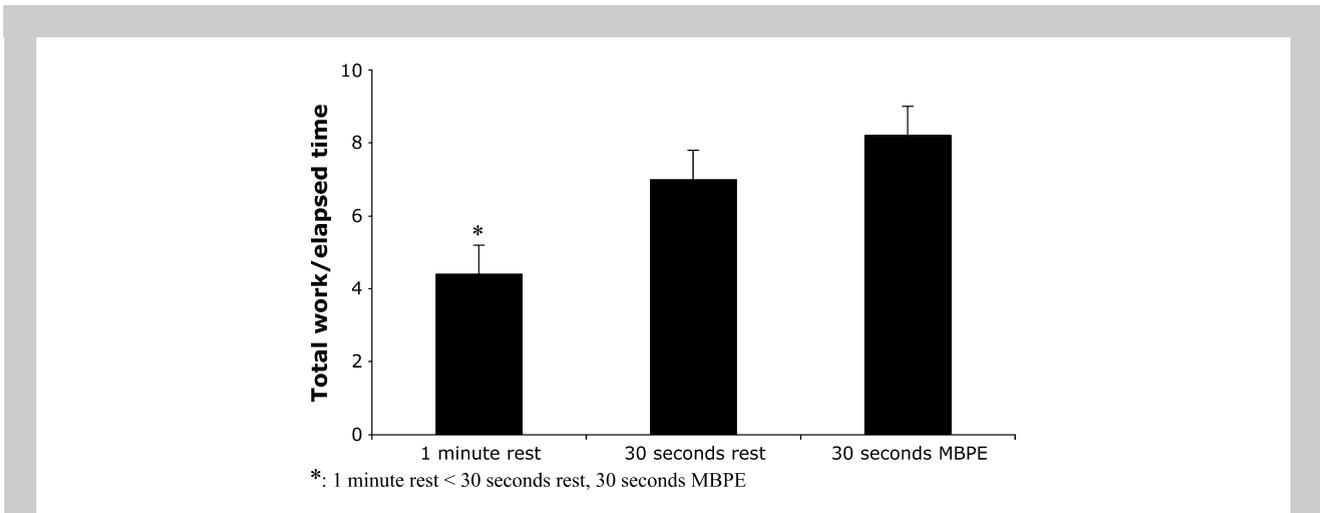


Figure 4. Barbell curl total work/elapsed time data (mean ± SEM) for each workout.

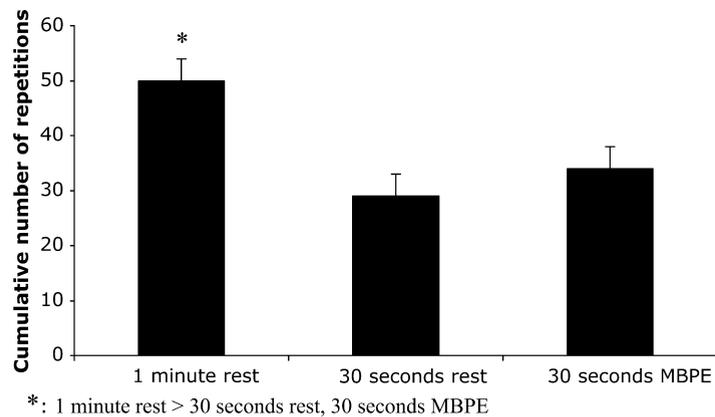


Figure 5. Cumulative number of leg press repetitions performed (mean \pm SEM) for each workout.

Calculation of Resistance Exercise Performance

For each exercise and workout, two dependent strength variables were calculated: the cumulative number of repetitions performed and a total work/elapsed time ratio. The cumulative number of repetitions performed was simply determined as the total number of repetitions done correctly per set, summed for the eight sets. Because 1-minute rest periods are twice the length of the other two examined in the current study, results could be affected, as longer rests between sets enable higher force outputs (26). To address this concern, a total work/elapsed time ratio was used as a second dependent variable. Its calculation entailed multiplication of the resistance and the number of

repetitions done per set, summed for all eight sets per exercise for an indirect assessment of the total work performed. That value was divided by the elapsed time required to perform the sets (rest periods included) to derive a total work/elapsed time ratio.

Statistical Analyses

Dependent variables were analyzed with one-way repeated-measures (ANOVA) to compare the mean differences among the three rest period treatments. An $\alpha = 0.05$ was used to establish statistical differences, and Tukey's post hoc test determined the source of the significance. At α and β values of 0.05 and 0.80, respectively, and with the large effect sizes

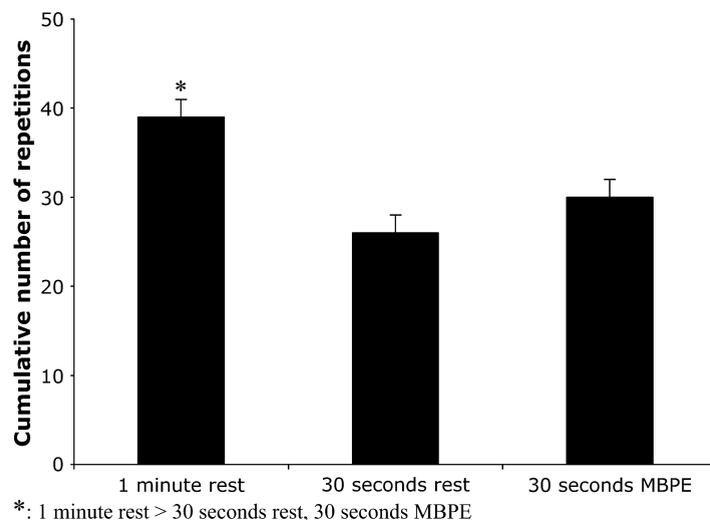


Figure 6. Cumulative number of leg curl repetitions performed (mean \pm SEM) for each workout.

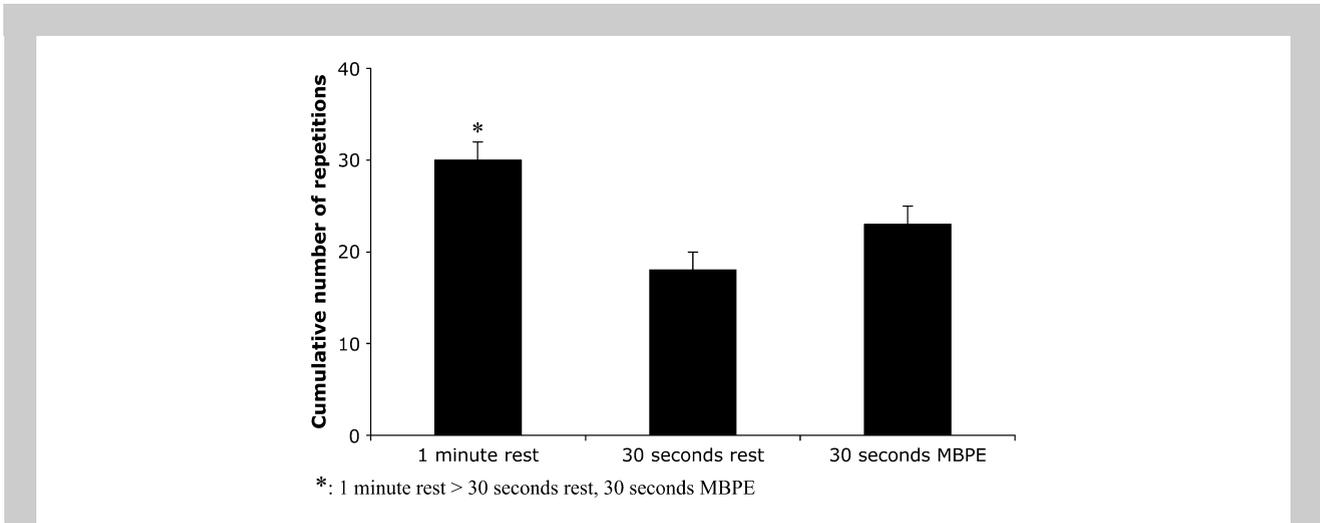


Figure 7. Cumulative number of shoulder press repetitions performed (mean ± SEM) for each workout.

typical of resistance exercise studies (3,17,20), the current study sample exceeded the estimated sample size required for statistical analysis (16). The assumptions required to perform the ANOVA computations (data normality, sample independence, homogeneity of variance) were met before analysis (16).

RESULTS

All 30 subjects completed the three workouts. No subjects were injured from their participation. Figures 1–4 show total work/elapsed time results for the leg press, leg curl, shoulder press, and barbell curl exercises. For each exercise, repeated-measures ANOVAs were statistically significant. Post hoc

analysis for each exercise showed the following results: 1-minute rest <30 seconds' rest, 30 seconds' MBPE. Results suggest that rest period duration had the greatest effect on total work/elapsed time ratio results.

The cumulative number of repetitions performed for the leg press, leg curl, shoulder press, and barbell curl exercises is shown in Figures 5–8, respectively. Like total work/elapsed time data, repeated-measures ANOVA cumulative repetition results were statistically significant for each exercise. Post hoc analysis for each exercise showed the following results: 1-minute rest >30 seconds' MBPE, 30 seconds' rest. The longer rest period enabled performance of significantly more repetitions.

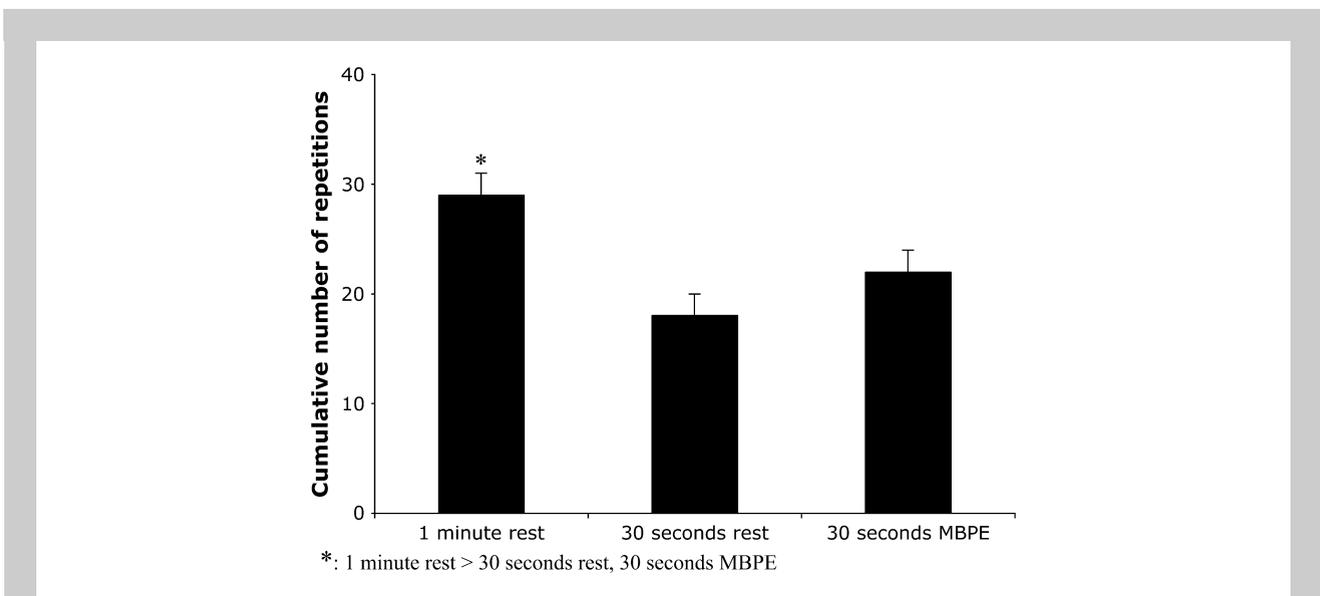


Figure 8. Cumulative number of barbell curl repetitions performed (mean ± SEM) for each workout.

DISCUSSION

The current exercises, coupled with a multi-set protocol, represent a bodybuilding-style workout. The goal of such workouts is hypertrophy, in which sets are terminated in part because of a decrease in muscle pH. Rest periods for such workouts may be shorter than 1 minute to maximize endogenous growth hormone secretion and elicit desired training adaptations (26). Substantial fatigue accompanies such workouts; thus, the study allows for the assessment of MBPE to abate fatigue and improve subsequent performance. Current results indicate that rest period duration has the greatest impact on exercise performance and that MBPE evoked insignificant changes versus rest periods of equal duration during which subjects stood upright.

Eastern Europeans administered massage to speed recovery from exercise (2,23). Yet despite the novel manner of massage application, our results agree with Western outcomes that show massage does not aid recovery from exercise-induced muscle damage, delayed-onset muscle soreness, or strength retention after bouts of anaerobic or eccentric actions (4,18,24). Massage was no more effective than muscle stretching or a passive control condition in abating delayed-onset muscle soreness from eccentric ankle extensor actions (18). Similar effects were noted with massage applied to the hamstring muscle group (12).

Resistance exercise increases intracellular levels of glycolytic metabolites. Cells operate under increasingly acidotic conditions as resistance exercise sets progress toward momentary failure, whereby ATP demand and hydrolysis far exceed levels seen at rest (7,10). Higher levels of the metabolite lactate result from greater fatigue and impaired performance. Lactate has been shown to act as a proton consumer and buffer against exercise-induced acidosis, which occurs, in part, from ATP hydrolysis (21). Lactate formation therefore serves as a by-product of metabolic acidosis (21). Massage was thought to enhance lactate clearance via greater intramuscular blood flow (5). However, recent studies question this claim (7,13). After exhaustive runs, subjects received a series of treatments to determine changes in lactate clearance (7). Blood lactate was measured before runs and 3, 5, 9, 15, and 20 minutes post exercise. Results showed passive recovery cleared lactate as well as postexercise massage, whereas 40% $\dot{V}O_{2\max}$ stationary cycling significantly improved lactate clearance compared with the other two treatments (7). Blood flow changes after concentric knee extensor actions were compared for subjects who received massage or control treatment post exercise (13). Results revealed that skin, but not femoral artery blood flow, was aided by massage (13). It was concluded that greater skin blood flow may divert blood from muscle and impede the rate of recovery (13).

As in the current study, massage was administered between sets of isometric knee extensor exercise to note its acute effects on subsequent resistance exercise performance (4).

Compared with a control rest period during which subjects sat passively, massage did not improve isometric performance, which concurs with current results (4). Massage was also less effective than active recovery for the restoration of exercise performance (4). Other studies also report the merits of active recovery (6,10,11). The effects of massage and active and passive recovery on lactate removal were compared after supramaximal exercise (10). Active recovery significantly lowered postexercise lactate half-lives vs. the other conditions (10). Massage and passive recovery resulted in similar lactate removal rates, despite the former's higher postexercise O_2 uptake among the three conditions (10). The effects of passive recovery resulted in the best clearance rate on lactate removal incurred from resistance exercise compared with active recovery (6,11). In summary, despite the novel manner of massage application used in the current study, our results question its merits and concur with outcomes from recent Western investigations (4,18,24).

Of the treatments examined, rest period duration had the most impact on resistance exercise performance. Current results both agree and disagree with studies that specifically examined the effect of rest period duration on the performance of exercise repetitions. Weight-trained men participated in a study to assess the effect of rest period duration on repetitive squats performed with 1RM loads (19). During three different workouts, subjects attempted two 1RM squats with 1-, 3-, or 5-minute rests between lifts (19). Results showed insignificant differences in the ability to repeat 1RM squats at different rest intervals. It was concluded that a 1-minute rest was sufficient to allow a 1RM squat attempt to be successfully repeated (19). A similar effect occurred with the bench press, as the ability to repeat a 1RM lift was compared with 1-, 3-, 5-, and 10-minute rests between sets (25). Results showed that the 1-minute periods permitted sufficient rest between 1RM bench press attempts (25).

In contrast to current results, previous studies found that shorter rest intervals were sufficient for successful performance of exercise repetitions (19,25). However, results were likely influenced by the resistance employed and the number of repetitions attempted per set. In contrast to studies that employed 1RM loads (19,25), the effect of rest period duration was recently examined with squats done for four sets at 85% of a 1RM load (20). Workouts were performed with a 1-, 2-, or 5-minute rest between sets. As in the current study, subjects were instructed to exert maximal voluntary effort as they performed as many repetitions as possible per set (20). Results showed that 5-minute rest periods led to a significantly higher cumulative number of repetitions performed than the other conditions (20). Results concur with current findings, in which longer rest intervals enabled performance of more repetitions. Thus, in the design of resistance exercise programs, particular attention should be paid to rest period durations, as they exert a great influence on performance.

PRACTICAL APPLICATIONS

Typical resistance exercise workouts are interspersed with rest periods. Massage is normally administered between workouts in an attempt to improve body restoration and athletic performance (2,5,8,23). Given the current study design and dependent variables measured, it is difficult to discern why the MBPE treatment was ineffective. Other studies that show massage to be ineffective are also at a loss to explain why (18,24). Recent findings indicate that the benefits of massage include sustained reductions in muscle tightness (14). Such an adaptation will not likely augment resistance exercise performance assessed in the current study. Improved blood flow is a perceived benefit to massage, yet research shows insignificant changes in response to the intervention (4,13). Current study blood flow may not have improved enough to affect lactate clearance and enhance recovery and subsequent exercise performance. Such an effect was also suggested in a previous study (7), but it cannot be confirmed as both the current and previous studies failed to measure blood flow. More research with invasive measures is required to discern why investigations (4,7,10,18,24) have failed to note physical recovery and performance improvements from massage administration.

Study results, combined with findings from the literature, suggest that active recovery is a viable alternative to massage to abate the acute build-up of exercise-induced metabolites and to hasten recovery (7,10). Our results show that rest period duration had the greatest influence on resistance exercise performance. Those who seek improved resistance exercise performance should pay particular attention to the duration of rest periods, as longer rests permit greater recovery and allow performance of more repetitions (26). Yet rest intervals longer than those required to evoke a given physiological adaptation may adversely affect performance and the rate or degree of improvement. Current results indicate that the use of acute anecdotal techniques such as MBPE is of little value.

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