Acute Heart Rate, Blood Pressure, and RPE Responses During Super Slow Vs. Traditional Machine Resistance Training Protocols Using Small Muscle Group Exercises

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Abstract

Wickwire, PJ, McLester, JR, Green, JM, and Crews, TR.[3] Acute heart rate, blood pressure, and RPE responses during super slow vs. traditional machine resistance training protocols using small muscle group exercises. *J Strength Cond Res* 23(1): 72–79, 2009–Acute cardiovascular and perceptual responses to Super Slow resistance training (SS) are not well understood. This study compared blood pressure (BP), heart rate (HR), and ratings of perceived exertion (RPE) between SS and traditional machine (TM) protocols. Participants ($n = 20$) completed three sessions of elbow flexion (EF) and knee extension (KE). Session 1 consisted of determining 1RM for EF and KE and a familiarization trial for the SS technique. Sessions 2 and 3 were counterbalanced, with subjects completing three sets of SS (10 seconds concentric, 5 seconds eccentric per rep, 40% 1RM) and TM (2 seconds concentric, 4 seconds eccentric per rep, 65% 1RM). Paramount resistance training equipment was used for both exercises. Peak HR was recorded for each set, with recovery HR taken between sets after 3 minutes of rest. Blood pressure was taken after 5 minutes of seated rest, after each set, before sets 2 and 3, and at 2 minutes post set 3. Ratings of perceived exertion for active musculature were obtained three times per set. Although systolic BP (SBP) and diastolic BP (DBP) responses were not significantly different between SS and TM for EF or KE, SBP (SS and TM combined) was significantly lower during EF and was significantly higher during KE than resting BP. Diastolic BP (SS and TM combined) was not significantly different from resting BP for EF or KE. Peak HR was significantly greater during TM (vs. SS) for EF and KE. Ratings of perceived exertion were also significantly greater during TM for EF and KE. Even though SBP was greater for SS and TM combined during KE, comparing SS and TM revealed minimal differences in BP. This suggests that, when performing small muscle group exercises with lighter weight at a slow speed, either SS or TM would be appropriate for individuals to whom strength training is not contraindicated.

Key Words weight training, slow resistance training, cardiovascular

Introduction

In a book entitled *Super Slow* (10), it is recommended that weight training exercises be performed in a very slow and calculated manner. To achieve this goal, it is suggested that one should perform the concentric phase of a weight training exercise for 10 seconds and the eccentric phase for 5 seconds. Since the publication of *Super Slow* in 1992, research examining this type of training program has been sparse. Despite the small amount of literature, Super Slow weight training (SS) has been purported to give its users many advantages. Some of these advantages include increases in strength and loss of body fat (4).

Westcott et al. (17) compared strength gains across 10 weeks between SS vs. those of Nautilus training. He used a 10-repetition maximum (10RM) test for the regular speed group and a five-repetition maximum (5RM) test for the SS group as measures of strength. This protocol involved a 2-second concentric phase and a 4-second eccentric phase. The 2- and 4-second cadence used by Westcott et al. (17) came from the weight training machine genre; throughout the remainder of this article, this cadence will be referred to as the traditional machine protocol (TM). The results show that SS made significantly greater gains in strength than TM. Conversely, Keeler et al. (11) have reported that traditional resistance training (repetitions not meeting any time requirements) showed superior results in strength than SS for various resistance training exercises. Supporting the results of Keeler et al. (11), Popper et al. (14) also found that traditional

resistance training produced significantly greater improvements in strength over SS using a 5RM measure of strength. Conflicting results could stem from the use of untrained subjects in Westcott et al. (17) and trained subjects in Popper et al. (14).

Acute cardiovascular responses (blood pressure [BP] and heart rate [HR]) to SS are also important to consider because of the extended amount of time spent under load, which could potentially increase cardiovascular demand (rate pressure product [RPP]). One study that attempted to measure cardiovascular responses of SS training was conducted by Frazier et al. (4). The goal of this investigation was to compare the chronic effects of SS resistance training vs. training with traditional aerobic exercise (TE) on resting BP. Subjects in this experiment trained for 16 weeks using one of the above protocols (SS or TE). Frazier et al. (4) found that TE showed greater improvements in resting BP than SS. The subjects used were not hypertensive; therefore, these results were arguably not as meaningful as if benefits had been demonstrated in an "at-risk" population. Hunter et al. (9) compared the HR response of SS with that of traditional resistance training (TM). Their results found that TM elicited a significantly greater acute HR response than SS during exercise and recovery. Despite the studies mentioned above, acute response of BP and perceptual effort between a traditional and SS training protocol would still be of importance. With this in mind, the current study compared acute BP, HR, and perception of effort between the SS and a TM protocol.

METHODS

Experimental Approach to the Problem

The equipment used to measure cardiovascular variables were an Omron wrist BP monitor (Omron Healthcare Inc., Vernon Hills, Illinois) and an Acumen HR monitor (Acumen Inc., Sterling, Virginia). A Paramount (Paramount Fitness Corp., Los Angeles, California) knee extension (KE) and elbow flexion (EF) machine were used for this experiment. Also, the Borg (6–17) category ratings of perceived exertion (RPE) were used to measure how difficult each exercise felt to the subject with perceptual estimations differentiated to feelings in the active musculature.

Subjects

Twenty subjects (11 men, 9 women) participated in the study. The subjects were apparently healthy (none had hypertensive starting points), college-aged individuals. Data-collection procedures were approved by the institutional review board of Western Kentucky University for the protection of human subjects. All participants were required to sign a written informed consent.

Procedures

The two lifts used for this investigation were EF and KE. The exercises chosen are fixed-form machine exercises; they were chosen because their form can be easily controlled as opposed to a free weight exercise such as the bench press. Furthermore, these exercises were chosen so that a muscle group from the upper and lower body would be incorporated. Three separate sessions were completed by each subject in a span of no longer than 8 days and at least 2 days of recovery between sessions. The individual sessions were administered as follows:

Session 1. On arrival, participants were measured for height, weight, body composition (bioelectrical impedance, Omron), resting BP, and resting HR. Resting BP and HR were assessed after a 5-minute period of seated inactivity.

After resting data, subjects were assessed to determine 1RM for KE and EF. This procedure was accomplished by using the guidelines set forth by the *ACSM's Guidelines for Exercise Testing and Prescription* (6th ed.) (1) as a general marker for load progression. Subjects performed a warm-up with light weight, rested about 5 minutes, and then performed a maximal-effort repetition. If they were able to accomplish the lift, the weight was increased, they rested for about another 5 minutes, and they attempted the lift again. This cycle was repeated until the subject was no longer able to complete a lift. The heaviest weight successfully completed a single time for EF and KE was recorded as a 1RM. After completion of the 1RM tests, subjects completed a familiarization trial with the SS training technique. This involved subjects performing the SS technique with minimal resistance. The seconds of the concentric and eccentric movements were verbally counted as in the following trials. Familiarization was completed on the basis of the assumption that subjects were unfamiliar with the SS training technique.

Super Slow Trial. Initially, the subjects' resting BP and resting HR were measured after several minutes of seated rest. Next, subjects began the resistance training aspect of the investigation on either the EF or KE exercise. The participants performed three sets of each exercise with 3–5 minutes of rest between each set and 5–8 minutes of rest between EF and KE. During SS, subjects completed repetitions to muscular failure with a weight set at 40% of their 1RM. Each repetition consisted of a 10-second concentric phase and a 5-second eccentric phase, with no pause taken between each repetition. To ensure protocol adherence, individual repetitions were timed with each second counted aloud verbally, with subjects being cued to increase or decrease velocity when needed. The total time to complete each set was recorded. Heart rate (5-second average) was assessed with the Acumen HR monitor. The intervals used included the following: peak HR for sets 1, 2, and 3 (PHR1, PHR2, and PHR3) and recovery HR post sets 1, 2, and 3 (RHR1, RHR2, and RHR3). Peak HR was recorded as the highest observed HR after each set. Recovery HR was recorded as the lowest observed HR between each set. Blood pressure was taken immediately after completing each set (P1, P2, and P3), 1 minute before starting sets 2 and 3 (Pr2 and Pr3) of each exercise, and 2 minutes after completion of the final set (2MP3) of each exercise. It must be

noted that the times given for the recording of BP are not exact because of the delay of the monitor between when the start button was pushed and when an actual BP measurement was given. Ratings of perceived exertion were taken at a beginning point (T1), a midpoint (T2), and near failure (T3) for each set. A definite point to obtain RPE could not be established because of the varying times it took the subjects to complete each set.

Traditional Machine Protocol Trial. The TM protocol session was administered in the same manner as the SS session except that the concentric and eccentric phases were 2 and 4 seconds, respectively (seconds of each repetition were counted aloud verbally, and no pause was taken between each repetition), and the resistance was set at 65% of each individual's 1RM. Because of the greater speed of the movement during this protocol, more repetitions were possible. All other aspects of the investigation were kept the same as in the previous session. Furthermore, SS and TM were counterbalanced between subjects.

The extremely slow velocity of SS made it impossible to perform a large percentage of 1RM. Therefore, a decrease in resistance was made to SS below that of TM in an attempt to balance the overall difficulty between the two protocols. Furthermore, the purpose of this study was to measure cardiovascular parameters while performing two different exercise protocols. This is why the different intensities were chosen, in addition to the obvious reason of different speeds of movement. In a study by Hoeger et al. (7), subjects were able to perform a high number of repetitions at 40 and 60% of 1RM during a leg press exercise and a moderately high number of repetitions during an arm curl exercise. Even though similar percentages of 1RM were used in the current study, the same high number of repetitions as accomplished by subjects in Hoeger's (7) experiment would not be expected with the slow speeds of movement that were used in this study. Although different intensities have been used in other SS literature, after performing pilot work it was decided that subjects could perform 40% of 1RM while using the SS protocol. To examine the specific differences between these protocols, total volume load (TV) and total time under load (TT) were calculated for each set. Total volume load was calculated by multiplying the number of reps accomplished for a given set by the amount of weight used during the same set. Total time under load was measured with a stopwatch throughout all sessions and recorded after each set.

Statistical Analyses

Data were analyzed using a repeated-measures (analysis of variance) ANOVA for between- and within-trial comparisons (SS vs. TM) for systolic BP (SBP), diastolic BP (DBP), HR, RPE, TV, and TT. When ANOVA indicated a significant difference, a Bonferroni post hoc procedure was used to detect specific differences between the variables in different trials. Results were considered significant at $p \leq 0.05$.

RESULTS

Subjects' descriptive characteristics are presented in Table 1.

Blood Pressure

Repeated-measures ANOVA for SBP indicated no significant differences between SS and TM for EF or KE (observed power for EF = 0.24 and for KE = 0.25). Also, no significant differences were found between SS and TM for DBP for EF or KE (observed power for EF = 0.14). Even though no significant differences were found between SS and TM for SBP or DBP during either lifting technique, SBP was significantly higher during KE vs. EF (observed power for SS = 0.73 and TM = 0.81). Figure 1 contains SBP for the comparison of the exercises. The significant differences between EF and KE were found at Pr2 (EF = 115 ± 16, KE = 134 ± 18) and P2 (EF = 117 ± 15, KE = 136 ± 21). During TM, the significant differences between EF and KE occurred at Pr3 (EF = 114 ± 13, KE = 130 ± 16), P3 (EF = 112 ± 17, KE = 130 ± 15), and 2MP3 (EF = 115 ± 14, KE = 127 ± 16). Figure 2 contains DBP for the comparison of the exercises. No significant differences were found between EF and KE for DBP (SS or TM; observed power for SS = 0.28 and for TM = 0.34). However, it is worth noting that DBP for KE still remained consistently higher than DBP for EF during SS and TM.
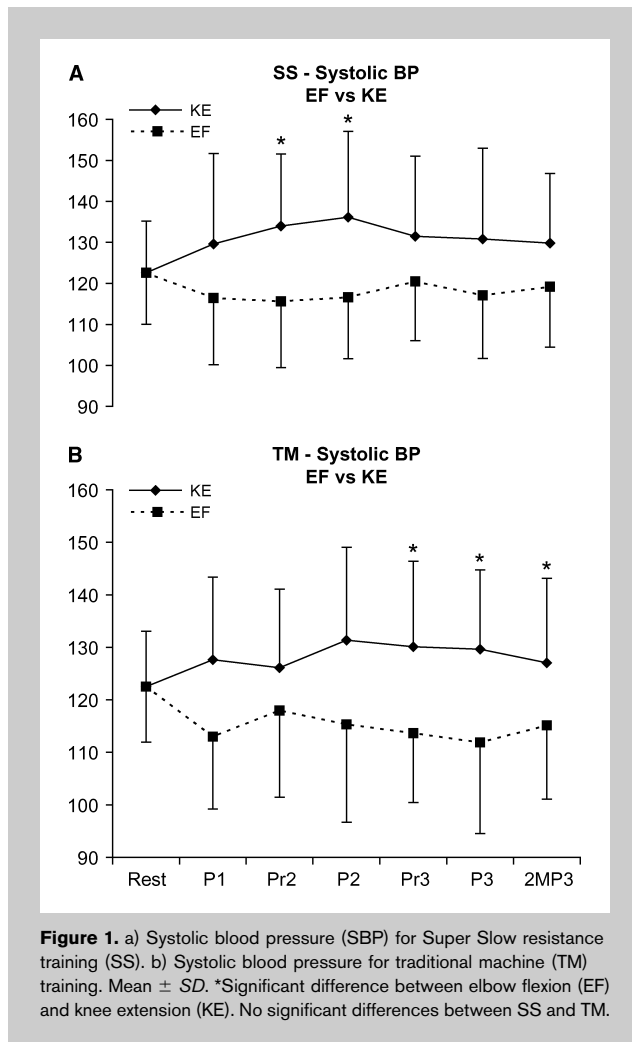
Heart Rate

Figure 3 illustrates the comparison of HR between SS and TM. Elbow flexion elicited a significantly greater HR during TM vs. SS at PHR1 (SS = 131 ± 18, TM = 144 ± 19). KE elicited a significantly greater HR during TM vs. SS at PHR1 (SS = 126 ± 23, TM = 139 ± 17) and PHR2 (SS = 133 ± 24, TM = 145 ± 17). Observed power for HR was 1.00 while performing both EF and KE.

Ratings of Perceived Exertion

Figure 4 shows the differences between SS and TM for RPE. The TM RPE was significantly greater than the SS RPE during EF at T2 (SS = 12.6 ± 2.5, TM = 16.0 ± 2.0) and T3

TABLE 1. Descriptive statistics ($n = 20$).

	Mean	SD
Age (y)	24.65	3.47
Height (cm)	174.07	9.88
Weight (kg)	73.18	16.53
Body composition (%)	16.56	4.82
Resting systolic blood pressure (mm Hg)	115.85	10.04
Resting diastolic blood pressure (mm Hg)	73.00	8.75
Resting heart rate (bpm)	70.60	10.62
Elbow flexion 1RM (kg)	53.41	27.22
Knee extension 1RM (kg)	94.46	34.07

Figure 1. a) Systolic blood pressure (SBP) for Super Slow resistance training (SS). b) Systolic blood pressure for traditional machine (TM) training. Mean ± SD. *Significant difference between elbow flexion (EF) and knee extension (KE). No significant differences between SS and TM.

Figure 2. a) Diastolic blood pressure (DBP) for Super Slow resistance training (SS). b) Diastolic blood pressure for traditional machine (TM) training. Mean ± SD. No significant differences between elbow flexion (EF) and knee extension (KE) or between SS and TM.

(SS = 16.9 ± 1.8, TM = 18.7 ± 1.8) for set 1, T1 (SS = 11.8 ± 2.0, TM = 13.9 ± 2.5) and T2 (SS = 15.1 ± 2.1, TM = 17.0 ± 2.0) for set 2, and T3 (SS = 18.1 ± 1.5, TM = 19.5 ± 1) for set 3. The TM RPE was significantly greater than the SS RPE during KE at T2 (SS=13.8 ± 1.8, TM=16.2 ± 1.9) for set 1. Observed power was 0.80 for EF and 1.00 for KE.
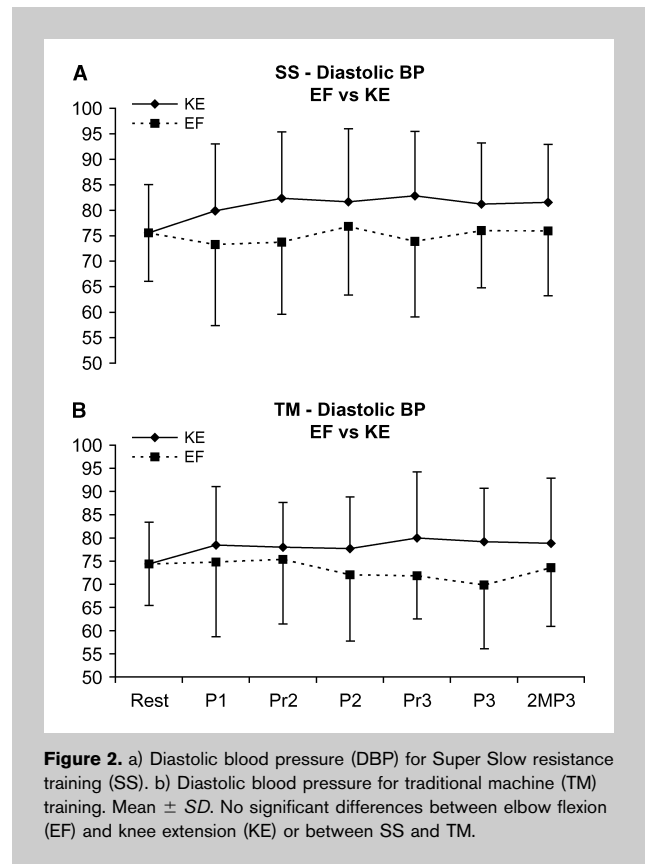
Total Volume Load

Figure 5 illustrates the differences between SS and TM for TV. For TM, TV was significantly greater than for SS for all sets and for both exercises. Observed power was 1.00 for TV during EF and KE (SS vs. TM).

Total Time Under Load

Figure 6 shows the differences between TT for SS and TM. For SS, TT was significantly greater than for TM for all sets and for both exercises.

Repetitions

Table 2 shows the amounts of repetitions accomplished by each subject for SS and TM. Subjects were able to perform a significantly greater amount of repetitions during TM as compared with SS.

Ratios of Heart Rate per Total Volume of Work

Ratios of HR per TV (HR/TV) were significantly higher for SS vs. TM for both exercises. This higher ratio during SS could suggest a higher cardiovascular strain while performing SS. However, care must be taken in the interpretation of HR/TV because HR and TV are not congruent. The ratios for SS could be artificially inflated, considering that HR has a lower and upper limit whereas TV can change immensely. Therefore, the remainder of this article will focus on more practical methods of determining cardiovascular strain.

DISCUSSION

The results show no significant differences in SBP or DBP between SS and TM. Therefore, neither regimen seems to present a greater danger than the other on the basis of BP readings taken immediately postexercise. However, the ratio between BP and TV would actually be higher during TM because of the greater amount of TV accomplished during TM.

It could be assumed that the Valsalva maneuver would be more likely to occur during SS. If the Valsalva maneuver did occur to a greater degree during SS, it could be expected that the BP response would be elevated during SS. However, the
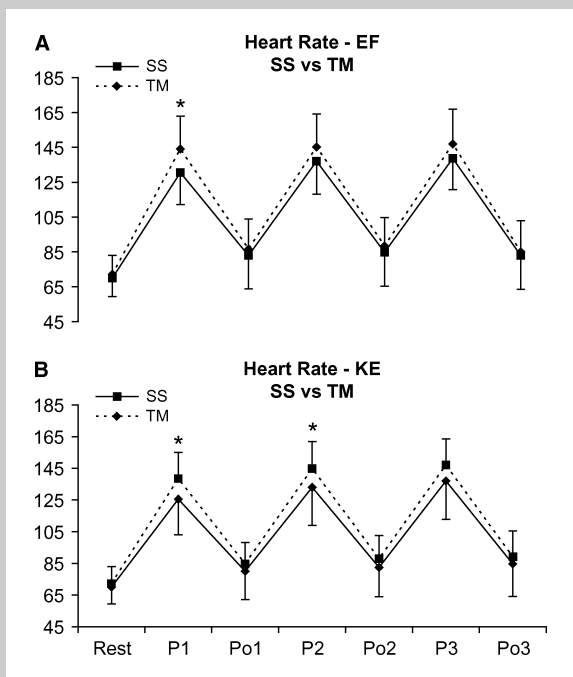
Figure 3. a) Peak and recovery heart rates for elbow flexion (EF). b) Peak and recovery heart rates for knee extension (KE). Mean ± *SD*. *Significant difference between Super Slow resistance training (SS) and traditional machine (TM) training.
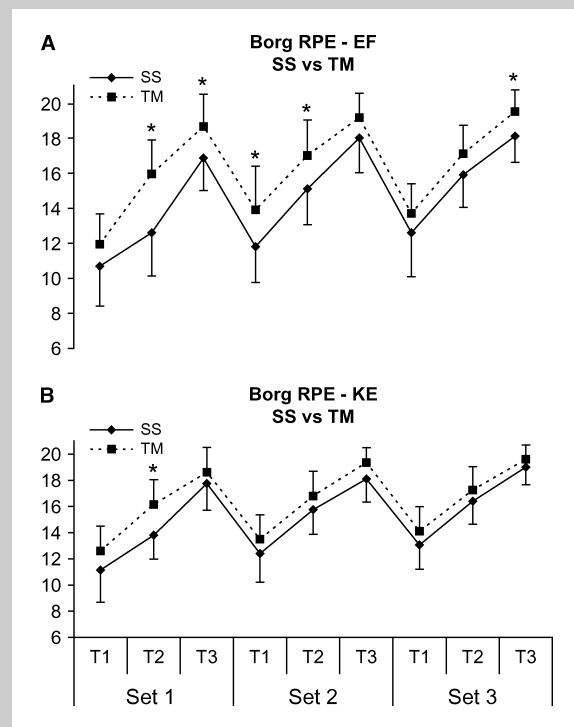

Figure 4. a.) Ratings of perceived exertion (RPE) for elbow flexion (EF). b) Ratings of perceived exertion for knee extension (KE). Mean ± *SD*. *Significant difference between Super Slow resistance training (SS) and traditional machine (TM) training.
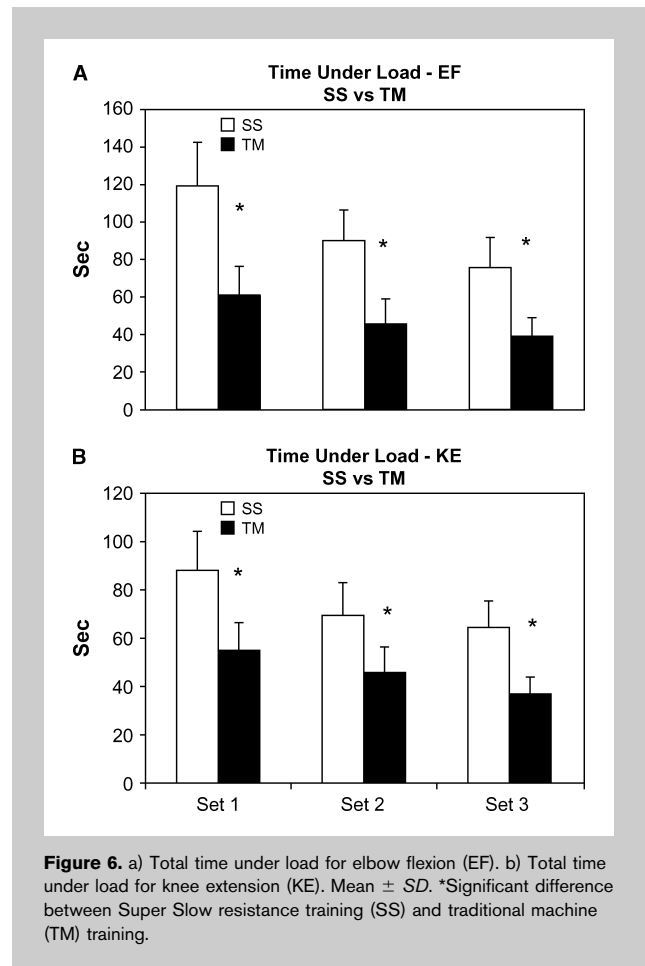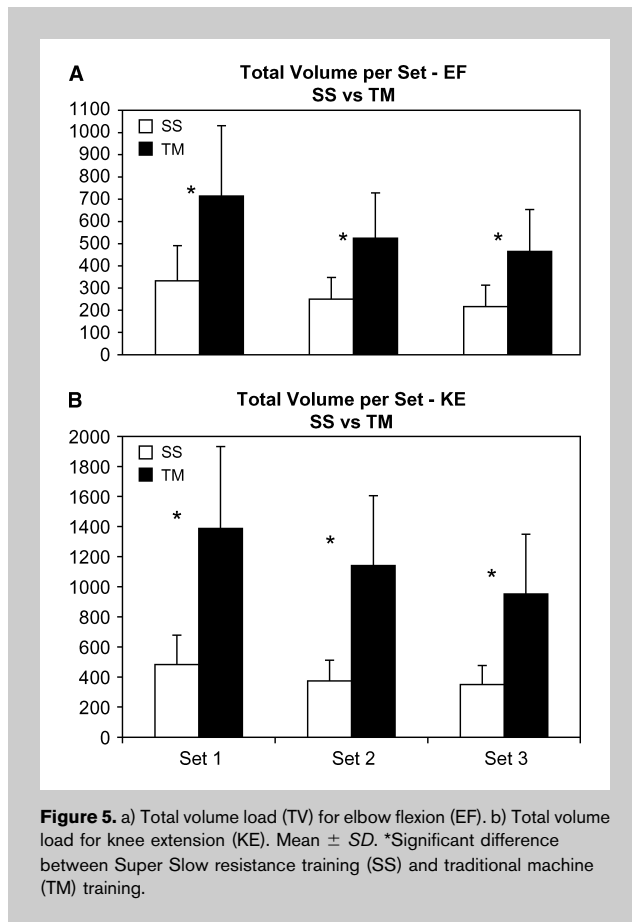
BP response was similar between SS and TM. This is consistent with a study by Heffernan et al. (6), which found that changes in BP were consistent between resistance exercise bouts and an experimental condition consisting of repeated Valsalva maneuvers. Therefore, a couple of speculations can be made from the current study and the study by Heffernan et al. (6). First, it could be speculated that the Valsalva maneuver does not contribute to an exaggerated increase in BP as might be expected. However, the more likely theory is that the Valsalva maneuver did contribute to an increase in BP in some subjects. Therefore, the Valsalva maneuver could have contributed equally among SS and TM.

Total volume load was much higher during TM vs. SS for both exercises. This higher TV during TM could lead one to assume that the subjects' BP responses would follow this increase. However, as mentioned before, there were no differences in BP between protocols. Pichon et al. (13) examined the differences in the BP response between circuit training and traditional weight training. In the study by Pichon et al. (13), the circuit training protocol had a greater total work load, which led to a higher metabolic cost. However, even though metabolic cost was higher, no differences were found in the BP responses of the subjects among the two weight training protocols. Therefore, it seems that a greater amount of work performed may not be a significant contributing factor in elevating BP. However, care should be taken when comparing the current study with

the study by Pichon et al. (13) because of the difference in the calculations used for the determination of TV (weight × reps) in the current study vs. the determination of work by Pichon et al. (13) ([weight of body segment × distance moved against gravity] + [weight of the bar and plates × distance moved against gravity]).

Furthermore, according to the results of this experiment, while performing EF, SBP decreased significantly from the resting value during SS and TM. However, while performing KE, SBP increased significantly above the resting value. A possible explanation for the decrease in SBP during EF could be that the subject experienced a vasodilation immediately after cessation of the exercise. Blood pressure was not measured during the contraction phases of the exercise, but a large increase in SBP would be expected. However, on completion of the exercise and relaxation of the active musculature, SBP may decrease, possibly because of vasodilation. As expected, there were no significant differences observed during SS and TM in DBP.

It is also plausible that menstrual phase variations of the female subjects may have skewed the SBP and DBP responses. However, according to Esformes et al. (3), there seems to be little difference in SBP and DBP across the menstrual cycle. According to Esformes et al. (3), there were no significant differences shown between the phases of

Figure 5. a) Total volume load (TV) for elbow flexion (EF). b) Total volume load for knee extension (KE). Mean ± SD. *Significant difference between Super Slow resistance training (SS) and traditional machine (TM) training.

Figure 6. a) Total time under load for elbow flexion (EF). b) Total time under load for knee extension (KE). Mean ± SD. *Significant difference between Super Slow resistance training (SS) and traditional machine (TM) training.

the menstrual cycle for SBP. However, there was shown to be a significant main effect for DBP during the early follicular phase, which showed that DBP was consistently lower during this early follicular phase than during other phases of the menstrual cycle. Still, there were not any significant differences found at any individual time points of BP responses between the various phases of the menstrual cycle. Furthermore, actual data should be considered to determine the practical differences in BP among the phases of the menstrual cycle. Mean DBP during the early follicular phase was 69 ± 4 mm Hg, 74 ± 3 mm Hg during the late follicular phase, and 72 ± 5 mm Hg during the midluteal phase. Therefore, the lack of a significant difference at individual time points and the lack of a practical difference in mean DBP values (as seen above) support the idea that menstrual phase variations do not play a major role in skewing BP responses in women.

The results of this study show that TM brought about

a significantly greater response in HR when compared with SS for both exercises. This response could have been attributable to greater resistance used during TM. It was thought that by increasing the resistance and the speed of TM, the overall difficulty would equal the decreased resistance and speed of SS. However, the greater resistance must have played a role in the greater HR response by TM. Also, the increased number of repetitions per set could have played a role in the greater HR brought about by TM (reps for SS and TM [Table 2]). However, on average, subjects could

TABLE 2. Reps accomplished for Super Slow resistance training (SS) and traditional machine training (average ± SD).

	Elbow flexion			Knee extension		
	Set 1	Set 2	Set 3	Set 1	Set 2	Set 3
SS	7.5 ± 1.6	5.8 ± 1.3	5.0 ± 1.3	5.9 ± 1.1	4.6 ± 1.0	4.3 ± 0.8
TM	10.1 ± 2.5	7.7 ± 2.2	6.8 ± 2.2	10.4 ± 2.0	8.5 ± 1.6	7.2 ± 1.5

not perform the same amount of repetitions as were performed by subjects in a study by Hoeger et al. (7). Even though similar percentages of 1RM were used in the current study as in the study of Hoeger et al. (7), the resulting lower numbers of repetitions accomplished were expected because of the slower speed of movement used. Furthermore, from Figure 5 it can be seen that TV is greater during TM than SS. This provides more evidence as to why HR was higher during TM vs. SS. This holds true despite the fact that TT was significantly greater during SS compared with TM (Figure 6). Therefore, this leads one to believe that the greater resistance must have played a significant role in the increased HR during TM. Although this outcome may have been anticipated, from a practical standpoint the resistances selected were similar to what might be used when employing the specific lifting techniques (SS and TM). Consequently, the ecological validity in the current design was magnified by applying such resistances. Had similar loads been applied for TM and SS, it is conceivable that the results may have been altered. However, the emphasis in the current study was to attempt to mimic, as closely as possible, the loads that might be selected for the different techniques, to determine what results might occur in typical SS and TM lifting paradigms.

It is also reasonable to consider the effect of menstrual cycle variations of the female subjects on HR. According to Esformes et al. (3), there were no differences in central hemodynamic variables (including HR) among menstrual cycle phases. Therefore, it is evident that menstrual cycles of the female subjects would not have a significant effect on HR.

Subjects perceived TM as more difficult than SS at each time point (Figure 4). It is plausible to hypothesize that SS would elicit a greater pain response attributable to a potentially greater ischemic response, which could possibly produce an elevated RPE. However, the results contradicted this hypothesis. Traditional machine training brought about a greater RPE or pain response than did SS (Figure 4). Pain causes an increase in adrenaline release. The increase in adrenaline will then cause an increase in the cardiovascular response (HR). However, it must be noted that adrenaline was not measured in this study. Because TM brought about a greater RPE, it can be speculated that the pain response was higher. Therefore, the greater response in HR for TM could be partially attributable to its greater RPE or greater pain response.

The initial goal before starting this study was to equate overall difficulty by adjusting the resistance and repetitions of SS and TM, respectively. However, it seems that the greater resistance during TM had an effect on the subjects' overall perceptions of effort. The subjects' RPE values were very likely driven by the pain experienced during the exercises. However, a pain scale was not incorporated, so no definite conclusions can be made in regard to pain.

As with HR, TV (Figure 5) seems to have played a role in the greater RPE experienced during TM vs. SS. Again, this holds true despite the fact that TT was significantly greater during SS as compared with TM (Figure 6). Therefore, the

resistance during TM must have been a principal factor contributing to the greater RPE during TM. This increased perception of effort and the possible increase in adrenaline release could have ultimately contributed to an increase in HR. All of these variables combined may have had an effect on the greater RPE experienced during TM. Because multiple factors influence perceptual responses, it is difficult to discern the precise reason for greater RPE during TM. One might consider menstruation of the female subjects to be a confounding variable that could have skewed perceptual responses. However, according to Stephenson et al. (15), changes in ovarian/uterine function during the menstrual cycle do not affect RPE at any exercise level.

The current results suggest that greater resistance has a more significant effect on RPE than does TT. The current findings are consistent with past research in that a higher percentage of 1RM elicited a higher RPE (2,5,12,16). However, it must be noted that in this previous research (2,5,12,16), subjects were only required to perform a certain amount of repetitions per percentage of 1RM, and not necessarily to failure. This is in contrast to the current study, in which subjects performed repetitions until volitional fatigue. Still, similar results were found in the current study regardless of the amount of repetitions accomplished or the speed at which the repetitions were performed. Further work is needed on perceptual responses during resistance training, particularly with different training techniques.

Rate pressure product can be determined by multiplying HR by SBP. Rate pressure product is indicative of the metabolic demand of the heart during exercise (8). Thus, factors that increase HR and SBP can increase the metabolic demand of the heart. In this experiment, EF elicited a lower SBP than the resting value, and KE brought about a higher SBP than the resting value during both protocols (SS and TM). Because TM elicited a significantly greater HR than SS, RPP could be greater while performing KE during TM, causing a greater metabolic demand on the heart. Conversely, because SBP was significantly lower during EF as compared with KE, RPP would be lower, resulting in a lower myocardial oxygen requirement. Super Slow resistance training did not produce an HR as great as that of TM. Therefore, RPP would probably be lower during SS. Finally, RPP should be given consideration when prescribing exercise to hypertensive populations. As regards this study, the greatest concern with RPP would be while performing KE during TM. As HR and SBP go down in SS while performing EF, RPP becomes less of a problem. However, it should be kept in mind that this variable was not measured because of the mismatched time points at which HR and BP were measured. Thus, no definite conclusions regarding exact demands placed on the heart during the different protocols can be made.

PRACTICAL APPLICATIONS

In conclusion, even though SBP was greater than resting SBP within SS and TM, there were no significant differences found

between the two training regimens. In future studies, BP should be measured during resistance training exercises incorporating SS. With HR, TM showed a greater response. Ratings of perceived exertion coincided with this rise in HR and with greater resistance. It seems that the greater resistance in TM elicited a higher subjective assessment of effort (RPE) or pain. This, along with the greater TV, could have contributed heavily to a greater HR. On the other hand, it is also a possibility that the increase in HR contributed more to the greater RPE experienced during TM. It must be noted that differing results could be seen if a complete training regimen (i.e., more exercises and more muscle groups used) were used. Furthermore, the results of this study should be interpreted in consideration of the small muscle group exercises (EF and KE) used. In other words, this study should not be used to generalize to exercises that employ multiple muscle groups (i.e., leg press). Therefore, future research warrants testing the variables used in the current study while using a complete training regimen. Also, more research should be done in this area incorporating weight training exercises that recruit numerous muscle groups.

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