The Acute Effects of Flotation Restricted Environmental Stimulation Technique on Recovery From Maximal Eccentric Exercise

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Abstract

Morgan, PM, Salacinski, AJ, and Stults-Kolehmainen, MA. The acute effects of flotation restricted environmental stimulation technique on recovery from maximal eccentric exercise. *J Strength Cond Res* 27(12): 3467–3474, 2013—Flotation restricted environmental stimulation technique (REST) involves compromising senses of sound, sight, and touch by creating a quiet dark environment. The individual lies supine in a tank of Epsom salt and water heated to roughly skin temperature (34–35° C). This study was performed to determine if a 1-hour flotation REST session would aid in the recovery process after maximal eccentric knee extensions and flexions. Twenty-four untrained male students (23.29 ± 2.1 years, 184.17 ± 6.85 cm, 85.16 ± 11.54 kg) participated in a randomized, repeated measures crossover study. The participants completed 2 exercise and recovery protocols: a 1-hour flotation REST session and a 1-hour seated control (passive recovery). After isometric muscle strength testing, participants were fatigued with eccentric isokinetic muscle contractions (50 repetitions at $60° \cdot s^{-1}$) of the nondominant knee extensors and flexors. Blood lactate, blood glucose, heart rate, OMNI-rating of perceived exertion for resistance exercise (OMNI-RPE), perceived pain, muscle soreness, and isometric strength were collected before exercise, after treatment, and 24 and 48 hours later. A multivariate analysis of covariance found that treatment had a significant main effect on blood lactate, whereas subsequent univariate analyses of variance found statistical significance with the immediate posttreatment blood lactate measures. The results indicate that flotation REST appears to have a significant impact on blood lactate and perceived pain compared with a 1-hour passive recovery session in untrained healthy men. No difference was found between conditions for muscle strength, blood glucose, muscle soreness, heart rate, or OMNI-RPE. Flotation REST may be used for recreational and professional athletes to help reduce blood lactate levels after eccentric exercise.

Key Words Epsom salt, lactate, knee extension, muscle strength

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27(12)/3467–3474

Journal of Strength and Conditioning Research

Introduction

To maximize overall performance, an athlete must focus on both training and recovery. However, this period of rest after a training session is frequently overlooked, and over time, this may lead to overtraining and underperformance. During immediate recovery from intense bouts of exercise, the body often experiences acute muscle soreness because of acidic conditions of the blood, or lowering of the blood's pH, that stems from an accumulation of lactic acid, lactate, or H^+ (2,5,14). To combat this increase and the decrement in performance after exercise, individuals often partake in 1 or more recovery techniques. Over the past decade, many recovery methods have been systemically investigated, including massage, cryotherapy, contrast water immersion therapy, active recovery, compression garments, and sleep (3). Several of these methods are associated with enhanced postexercise muscular recovery and performance along with a concomitant reduction in blood lactate (1,9,15,19,23,38). Each of these methods have limitations, such as risk of further tissue damage with massage, potentially extreme discomfort from cryotherapy or contrast water immersion, or the expense of numerous compression garments. Furthermore, all these techniques have a small effect size.

However, a relatively unexplored method of recovery, flotation restricted environmental stimulation technique (REST), may have a greater effect size and fewer limitations. Flotation REST involves reduction of environmental stimuli so that the human senses of sight, sound, and touch are compromised. The use of flotation has been in use since its invention in 1977 by John C. Lilly, in which the participant floated in a warm water and Epsom salt solution (33). The individual floats supine in an enclosed or open vinyl-lined tank with no light and water heated to roughly skin temperature (34–35° C) by a waterbed heating system. Participants float with arms to their side to mitigate the sensation of touch via their hands against their body and the surrounding environment (13,35). The tanks are not airtight and are filled with roughly 757.08 L of water mixed with 362.87 kg of Epsom salt so that the individual is capable of floating. The water is filled with Epsom salt (magnesium sulfate, $MgSO_4$) to a concentration (1.81 kg:3.79 L) considerably higher than that of the Dead Sea, allowing for effortless flotation in a solution that does not cause skin irritation (12).

Flotation REST has been used for a variety of ailments that include chronic pain (16), anxiety (16), and hypertension (13,18,34). It has also been used as a stress management medium to lower blood pressure, heart rate, and increase muscle relaxation for an overall sense of better well being (11). However, no studies, to the current knowledge of the researchers, regarding flotation REST and recovery from intense exercise have been performed. This is important because flotation REST has previously shown decrements in heart rate (11), blood pressure (13,18,34), and lactate (31). Therefore, the purpose of this study was to determine the effects of flotation REST on the recovery from an acute bout of strenuous eccentric knee extensions and flexions compared with a seated passive recovery. It was hypothesized that there would be a reduction in blood lactate, heart rate, perceived exertion, and perceived pain with enhanced recovery of knee extensor and flexor isometric strength with greater alleviation of delayed onset muscle soreness (DOMS) after a 1-hour session of flotation REST compared with a passive recovery period.

Methods

Experimental Approach to the Problem

To investigate the effects of REST on recovery, a randomized crossover design was used where each participant acted as their own control. For the purposes of this study, we intended to use healthy normal population individuals before including a specialized population of either unhealthy or athletic populations. These untrained men were asked to participate to determine if the experimental protocol will show a change in the normal population before testing a specialized population (i.e., athletes). Women were not included in this study because of the variation of hormone levels that takes place as part of the menstrual cycle, which may have interfered with the study such as altering glucose levels. Untrained participants underwent baseline anthropometric, performance, and metabolic measurements followed by an eccentric muscle damaging protocol of the knee extensors and flexors. It is well established that unaccustomed eccentric exercise elicits DOMS (4,6,25). The muscle damaging protocol and the assessment of torque were conducted using the same device to increase the specificity of testing (36). Isometric strength testing occurred over the 3 days of in laboratory testing throughout both protocols to validate the outcome of the muscle damaging protocol. Blood lactate, blood glucose, and heart rate were measured before any testing, after the muscle damage protocol, and after the treatments to determine the effect of either the seated control or the flotation REST treatments. To gauge metabolic strain and recovery from the muscle damaging protocol, glucose and lactate were measured. Furthermore, high accumulation of lactate is associated with muscle fatigue (2). Therefore, decreases in the amount of lactate may be indicative of better recovery and better performance as previous research has observed improvements in resistance exercise performance associated with lower lactate levels (1,9). OMNI-rating of perceived exertion for resistance exercise (OMNI-RPE) (28), perceived pain scale (8), and a 100-mm Visual Analog Scale (VAS) to measure DOMS were used to determine the effect the treatments had on the individual's perceptions of effort and soreness.

Subjects

Participants completed a detailed medical health history form to screen for any health issues that may prevent them from safely partaking in the study. Twenty-four healthy men (23.29 ± 2.1 years, 184.17 ± 6.85 cm, 85.16 ± 11.54 kg) from a large Midwestern University participated in this study. Participants were explained all procedures and were given time to ask questions regarding the study. Participants were college-aged students who were screened for exercise habits and deemed untrained if they performed resistance exercises less than 3 $d \cdot wk^{-1}$ (17). Men who had a body mass index (BMI) greater than 29.9 were excluded as those with a BMI of 30 and higher are categorized as obese and are at a significantly greater risk of cardiovascular disease, hypertension, poor cholesterol ratio, and mortality (10). Individuals were also excluded if they have had recent surgery, a history of any knee pathologies (i.e., ligament tears), or medical condition in regards to the knee (i.e., chronic hyperextension of the knee, surgical alteration, or injury). Individuals who had a history of claustrophobia were also unable to participate because of the conditions of the experimental environment. Participants provided written informed consent after reading an informed consent document and having all questions answered regarding the study. This study was approved by the institutional review board.

Procedures

After receiving details of the study, participants signed an informed consent, completed a physical activity questionnaire, and completed an extensive medical health history questionnaire. Participants were familiarized with testing for all dependent variables: maximal isometric strength, heart rate, blood lactate, blood glucose, blood pressure, OMNI-RPE (28), and perceived pain. Both experimental and control testing sessions took place on 3 consecutive days. Participants returned 1 week after completing the first 3-day session for the second 3-day testing phase. Day 1 of the experimental and control sessions were completed in 2 hours, whereas the visits on days 2 and 3 were 30 minutes in duration. Participants were instructed to refrain from any physical activity 3 days before any testing, during the duration of the study, and to maintain routine diet and sleep patterns. A 7-day physical activity recall questionnaire was completed before beginning the study to determine if previous strenuous activity may hinder their muscular performance (30). Participants were also instructed to refrain from eating 2 hours before testing, including caffeine, and for the duration of the first day's testing session (2 hours). Before testing, standing height (Seca 220 Telescopic Height Rod; Seca Corporations, Hamburg, Germany), body weight (T500E Athletic Scale; A&A Scales LLC, Prospect Park, NJ, USA), heart rate (Polar Vantage XL; Polar Electro Inc., Lake Success, NY, USA), blood pressure (Omron Health Care, Inc, Bannockburn, IL, USA), and simultaneous measurements of blood glucose and blood lactate (YSI 2300 Stat Plus Glucose/L-Lactate Analyzer; YSI Inc., Yellow Springs, OH, USA) took place for baseline data.

Participants performed a 5-minute warm-up on a cycle ergometer at 50 rpm before any muscular strength measurements. Initial isometric strength assessment took place to determine maximal force production of the knee extensor and flexor muscles of the nondominant leg. All testing took place using the Humac Norm Testing and Rehabilitation System (CSMi, Stoughton, MA, USA). The machine was calibrated according to the CSMi's user manual before each day of testing. The participants sat with the back angle of the chair set at 90° during the isometric knee extension and flexion strength assessment, and during the maximal eccentric knee extension and flexion exercise (27). The maximal isometric knee extension and flexion strength assessment was performed 3 times with the knee flexed at 60° for both the knee extensors and flexors and held for 5 seconds to measure maximal isometric force of the extensors and flexors (20,22,24,37). Participants were asked OMNI-RPE and perceived pain. The participants were given a 3-minute rest period after the initial strength assessment before performing a maximal eccentric knee extension and flexion exercise protocol (50 repetitions at $\cdot 60^\circ \cdot s^{-1}$) (4). Blood glucose, blood lactate, and heart rate were measured after exercise. All participants were given water ad libitum immediately after the maximal eccentric knee extension and flexion exercise. Either the 1-hour seated passive recovery control or the 1-hour flotation REST session took place followed by an assessment of strength, measurements of blood glucose, blood lactate, heart rate, OMNI-RPE, and perceived pain. During the seated control, participants were asked to remain seated in the Neuromuscular Laboratory under the supervision of the researcher and were allowed to use cellular devices, complete homework, or use a personal computer. Participants returned after 2 days for isometric strength testing and measurements of OMNI-RPE, perceived pain, and DOMS using a 100-mm VAS.

Table 1. Baseline data for passive recovery and flotation restricted environmental stimulation technique conditions, $N = 24$.

Variables	Mean ± *SD**
Muscle strength extension, N·m	232.16 ± 54.05
Muscle strength flexion, N·m	112.32 ± 24.39
Blood glucose, $mg \cdot dL^{-1}$	86.99 ± 11.1
Blood lactate, $mmol \cdot L^{-1}$	1.50 ± 0.34
Heart rate, $b \cdot min^{-1}$	73.73 ± 7.01
Rating of perceived exertion knee extension	6.03 ± 1.8
Rating of perceived exertion knee flexion	6.06 ± 1.86
Level of perceived pain knee extension	0.41 ± 0.66
Level of perceived pain knee flexion	0.35 ± 0.54

*Values averaged from 2 series of baseline measurements.

Flotation Tank

Participants entered a 844.15-L galvanized water tank that measured 2.13 m long, 0.76 m wide, and 0.61 m deep (Freeland Industries Inc., Portage, WI, USA). The galvanized water tank was filled with 529.96 L of water and mixed with 254.01 kg of Epsom salt (San Francisco Bath Salts Co., San Francisco, CA, USA). After the first 10 uses of the tank, an additional 22.68 kg of salt was added to maintain the proper salinity of tank because of salt being lost when participants exit the tank as it adheres to the body and hair. Brief showers were required before and after treatments.

The room in which the tank was held was dark during treatment and in level of the building to keep noise to a minimum. A Green Ecology Home (model GW 302) 3-stage

Table 2. Muscle strength knee extension and flexion (N·m), $N = 24$.

Variables	Treatment	Mean ± *SD*
Baseline extension		232.16 ± 54.05
Posttreatment extension*	Control	242.12 ± 65.46
	Float	223.00 ± 58.03
24 h posttreatment extension	Control	239.26 ± 55.74
	Float	228.68 ± 54.45
48 h posttreatment extension	Control	229.05 ± 56.98
	Float	236.93 ± 71.32
Baseline flexion		112.32 ± 24.39
Post treatment flexion	Control	98.81 ± 30.91
	Float	95.79 ± 29.93
24 h posttreatment flexion	Control	101.08 ± 26.7
	Float	100.95 ± 28.37
48 h posttreatment flexion	Control	99.74 ± 31.89
	Float	100.97 ± 37.14

*$p < 0.05$.

ultraviolet light–treated filtration system (SunSun Industry Co., Ltd, China) was used to aid in sanitation of the sterile Epsom salt and water solution, whereas an 800-W True Temp heating system with digital controller (JBJ USA Aquarium Products, Inglewood, CA, USA) created a water temperature of 34–35° C. The heating system was removed during all flotation sessions so that the participants did not burn themselves on the titanium heating rod. Average water temperature was 34.8° C.

Two space heaters, the Sunbeam Compact Heater (model SFH111-wm; Jarden Corp., Rye, NY, USA) and the Patton Milkhouse Utility Heater (model POH-680; Jarden Corp.), were used to heat the room to 26.6° C to help to maintain. The temperature of the room was measured using the Davis Perception II Weather Station (Davis Instruments Corp., Hayward, CA, USA). The lights in the flotation and adjacent room were turned off during each session, with a small light in the corner of the flotation room for the participant in case they needed to exit the tank early. A researcher was in an adjacent room during the flotation session to provide privacy for the participant while still supervising the experiment using the MobiCam AV (model 70060) infant monitor equipped with night vision (Mobi Technologies, Inc., Culver City, CA, USA). Before entering a tank, each participant read a script giving them instructions and informing them of video monitoring before their 1-hour flotation REST session.

Statistical Analyses

The statistical analysis consisted of a multivariate analysis of covariance (MANCOVA) to determine if there were any statistically reliable mean differences between the independent variables for multiple dependent variables using baseline measurements as covariates. Dependent variables included muscle strength (in Newton meter), blood glucose (in milligrams per deciliter), blood lactate (in millimoles per liter), heart rate (in beats per minute), pain intensity, and OMNI-RPE. Each variable was analyzed during specific time periods (e.g., postexercise, posttreatment, 24 hours, 48 hours). A multivariate analysis of variance (MANOVA) was used to determine if any significant differences of DOMS occurred between the 2 categorical independent groups. Statistical significance was set at $p < 0.05$ for all analyses. Statistical analyses were completed using SPSS Statistics 19.0 Premium (SPSS Inc., Chicago, IL, USA).

Results

Baseline values for muscle strength, OMNI-RPE, and perceived pain were calculated as the average of 6 measurements taken on 2 separate days separated by 1 week. The baseline values for blood glucose and blood lactate are averages of 4 measurements taken on 2 separate days separated by 1 week. Heart rate values are averages of 2 measurements taken before exercise on 2 separate days separated by 1 week (see Table 1).

Muscle Strength

The MANCOVA did not reveal a significant main effect for treatment with either the knee extension or the flexion measures. A follow-up univariate analysis of variance (ANOVA) revealed a significant main effect for the posttreatment knee extension ($F_{1,45} = 4.629$, $p = 0.037$, $\eta^2 = 0.093$). Power to detect the effect was 0.558. No statistical significance was observed at any of the subsequent time intervals. The mean torque elicited by the knee extensors was greater during the control than the flotation treatment at the posttreatment interval (19.12 N·m; control 242.12 ± 65.46 vs. float 223 ± 58.03) and the 24-hour interval (10.58 N·m; control 239.26 ± 55.74 vs. float 228.68 ± 54.45). The 48-hour interval showed a greater mean torque value for the flotation treatment (7.88 N·m; float 236.93 ± 71.32 vs. control 229.05 ± 56.98) (see Table 2). No statistical significance was observed for any of the knee flexion measures during follow-up ANOVA tests (Figures 1 and 2).

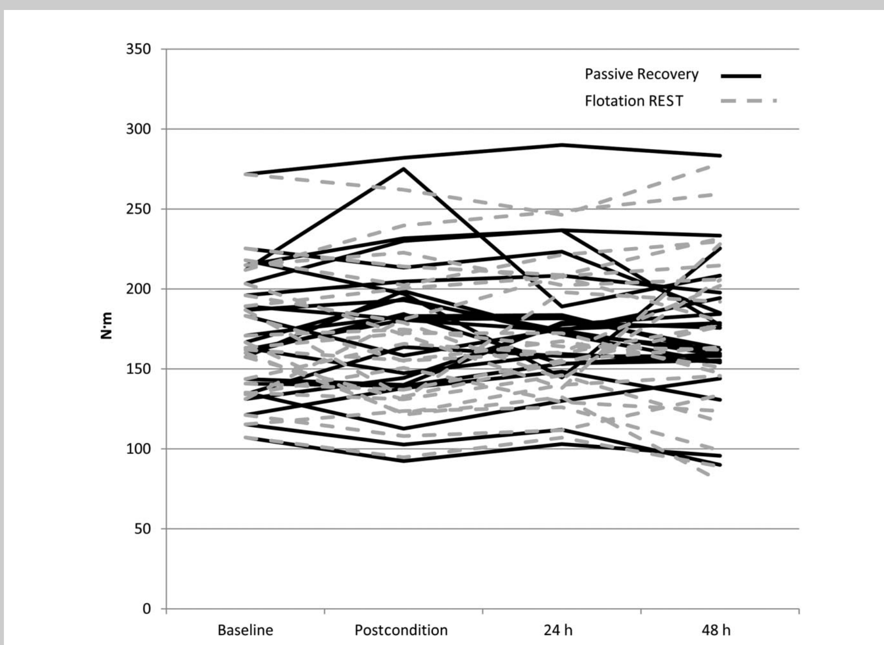

Figure 1. Knee extension (N·m) of passive recovery and flotation restricted environmental stimulation technique (REST) conditions, $N = 24$.

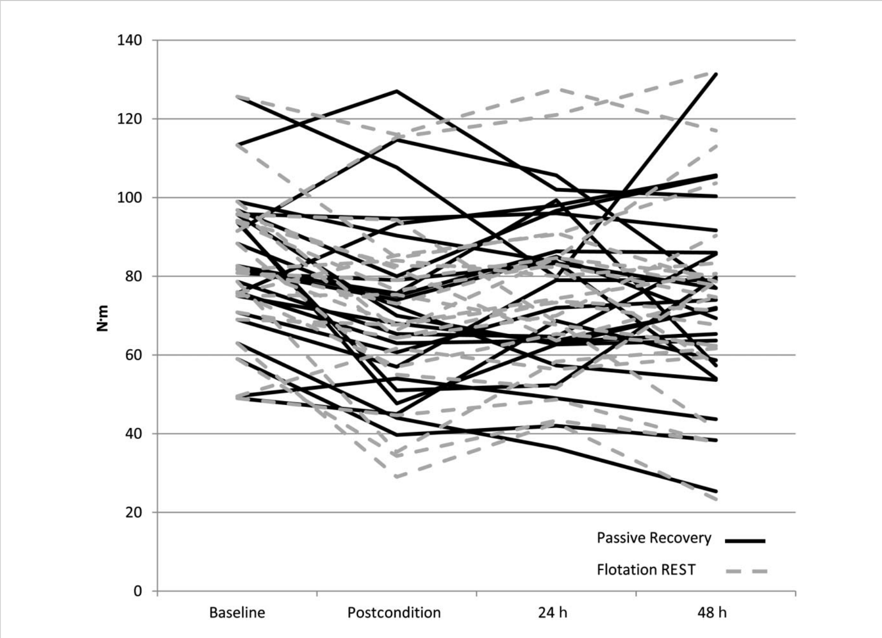

Figure 2. Knee flexion (N·m) of passive recovery and flotation restricted environmental stimulation technique (REST) conditions, $N = 24$.

Metabolic Variables

A MANCOVA revealed a significant multivariate main effect-for treatment on blood lactate (Wilks' $\lambda = 0.768$, $F_{5,42} = 2.479$, $p = 0.023$, $\eta^2 = 0.232$). Power to detect the effect was 0.776. Therefore, the hypothesis concerning lactate is confirmed. A follow-up univariate ANOVA revealed that the treatment had a statistically significant effect on blood lactate levels immediately after the treatment ($F_{1,45} = 10.356$, $p = 0.002$, $\eta^2 = 0.187$). Power to detect the effect was 0.883. No other statistical significance was observed. Mean blood lactate immediately after the flotation treatment was 0.66 mmol·L^{-1} lower than that of the seated control (float 1.11 ± 0.27 vs. control 1.77 ± 0.98), but blood lactate was found to be higher than the control treatment 24 hours (0.2 mmol·L^{-1}; float 1.62 ± 0.55 vs. control 1.42 ± 0.52) and 48 hours (0.12 mmol·L^{-1}; float 1.44 ± 0.64 vs. control 1.32 ± 0.36) after flotation treatment (see Table 3). The MANCOVAs performed on blood glucose and heart rate did not show a significant main effect for treatment, but statistical significance when performing a follow-up ANOVA was observed for 24 hours posttreatment heart rate ($F_{1,45} = 4.361$, $p = 0.042$, $\eta^2 = 0.088$). Power to detect the effect was 0.533.

Table 3. Metabolic variables of blood glucose (mg·dL^{-1}) and blood lactate (mmol·L^{-1}), $N = 24$.

Variables	Treatment	Mean ± *SD*
Baseline glucose		86.99 ± 11.1
Postexercise glucose	Control	79.48 ± 10.76
	Float	78.39 ± 4.41
Posttreatment glucose	Control	79.15 ± 8.98
	Float	75.66 ± 7.46
24 h posttreatment glucose	Control	82.79 ± 11.92
	Float	84.59 ± 14.84
48 h posttreatment glucose	Control	80.91 ± 7.41
	Float	83.56 ± 14.44
Baseline lactate		1.50 ± 0.34
Postexercise lactate	Control	2.87 ± 1.21
	Float	2.94 ± 1.04
Posttreatment lactate*	Control	1.77 ± 0.98
	Float	1.11 ± 0.27
24 h posttreatment lactate	Control	1.42 ± 0.52
	Float	1.62 ± 0.55
48 h posttreatment lactate	Control	1.32 ± 0.36
	Float	1.44 ± 0.64

*$p < 0.05$.

Perceptual Scales

The MANCOVAs performed on OMNI-RPE did not reveal any significant effect for either the knee extension or the knee flexion variables. A follow-up ANOVA revealed a significant effect on pain perception during knee extension at the posttreatment interval ($F_{1,45} = 7.004$, $p = 0.011$, $\eta^2 = 0.135$) with a power of 0.736. Mean pain level during knee extension after flotation was lower by 0.57 (float 0.46 ± 0.72 vs. control 1.03 ± 1.42) on the 0–10 scale. Conditions were not significantly different at any other time point. The MANOVA revealed no significance regarding DOMS between treatments.

Discussion

The purpose of this study was to determine the effects of flotation REST after an acute bout of strenuous eccentric knee extensions and flexions. We measured knee extension and flexion, blood lactate, heart rate, perceived exertion, and perceived pain. Researchers hypothesized a reduction in extensors and flexors with greater alleviation of DOMS after a 1-hour flotation REST condition compared with the seated passive recovery period. Delayed onset muscle soreness was measured over 6 days after the muscle fatigue protocol, whereas other variables were assessed after the immediate 1-hour recovery period.

Statistical analyses found significance between the type of treatment and the immediate posttreatment mean values for knee extension force production (in Newton meter). The mean force production elicited by the knee extensors was greater during the control than the flotation treatment by 8% and was deemed significant during the immediate posttreatment. It appears from this study that force production of the knee extensors is somehow compromised after a 1-hour flotation REST session. This may be because of an increased state of relaxation stemming from floating with minimal environmental stimulation (11,13,16,35). Indeed, the reduction in environmental stimuli that is experienced during flotation REST has been used as a stress management tool with the primary goal of increased muscle relaxation (11).

The metabolic variable blood lactate shows a response similar to those seen in previous research (31) and expected physiological responses. Mean blood lactate was significantly different at the posttreatment time point. It seemed that blood lactate had a steady decrease throughout the control treatment. Lowered blood lactate after flotation REST is consistent with previous research (31) where a 25% decrease in blood lactate was observed after a 1-hour flotation session without exercise before flotation.

Blood glucose had an average decrease of 11.33 $mg \cdot dL^{-1}$ from baseline when measured after the flotation session compared with 7.84 $mg \cdot dL^{-1}$ mean change after the seated control. The difference, while not significant, may be explained by the lack of sympathetic nervous system stimulation (11). Specifically, the lack of arousal in the sympathetic nervous system may hinder epinephrine secretion, which stimulates glucose production. Therefore, the liver may not be able to readily produce and release glucose into the blood stream. Another potential consideration is the increased need of glucose by the brain, as it has been suggested that increased oxygen and glucose could be available to the brain during flotation REST allowing for the increased state of relaxation and enhanced mood (31). Glucose metabolism of the brain during rapid eye movement stage of sleep, a state similar to the profound relation achieved during flotation REST, is similar to that of wakefulness (21). Fourteen of the 24 (58.3%) subjects fell asleep during the hour-long flotation session, whereas all were awake during the control. The quality of sleep was not determined but is be an interest for further exploration. Coupled with the decrease in sympathetic nervous activity, it may be possible that cerebral glucose utilization further augments the decrement in blood glucose.

It is likely that a lack of sensory stimuli in the flotation REST treatment dampens arousal of the central nervous system thus leading to an increased state of relaxation (31). Although this is ideal for an individual trying to achieve this rested state, it does have the consequence of dampening the one's sense of proprioception, which provides information about the body's physical position and motion and is essential to athletic performance (26). Proprioception is a function of the somatosensory system, which allows stimuli to travel to the central nervous system to be processed (26). As proprioception is likely compromised during flotation REST, it is possible that those being treated with this procedure may not be able to produce large amounts of force in the immediate posttreatment period. Indeed, this is what was observed in the current study for the knee extensors and may also be true for the knee flexors, although no significance was seen between treatments. In short, the combined effects of decreased proprioception and impaired motor control from a lack of stimuli to the central nervous system (31) may explain the significantly lower mean value of the knee extensors and knee flexors during the posttreatment measurements.

The mean rate of perceived exertion values were not deemed significant, but it is noted that the mean rates of perceived exertion seem to be slightly lower for the knee extension and knee flexion during the flotation treatment. This may be attributed to enhanced feelings of relaxation that were witnessed in previous literature (16,31). Pain intensity values were statistically significant treatments at the posttreatment measurement. The reduction in muscle pain is congruent with other studies that have shown reductions in pain for several hours after REST treatment in patients with chronic whiplash disorders (12,35).

Delayed onset muscle soreness, as measured by the VAS, was greater during all the control treatment measurements except for the 48 hours postmeasurement. The strenuous resistance exercise protocol had the expected effect on soreness as DOMS peaked 48 hours after both treatments and began to subside in the remaining days. However, no significant difference between treatments was observed for DOMS, but soreness was evidently lower for many of the participants. On returning to the laboratory after the flotation treatment, participants stated (unprompted) that they felt less sore in the days after the flotation than during the seated control. As stated above, flotation REST has been effectively used as a pain control technique and to treat those with chronic pain (16,35). It is conceivable that such reductions in pain are related to enhanced relaxation experienced during flotation REST. Although this experiment was not designed for pain control, the added analgesic effect of flotation REST may provide additional rationale for the use of this technique. Although no research has been found regarding flotation and perceived soreness with elite athletes, according to various web pages (i.e., floattank.com, thefloatcenter.com), professional athletes have claimed use of flotation to enhance recovery and improve performance.

This study provides novel data on the physiological and psychological responses to flotation REST; however, the data are not without limitations. The primary limitation of this study was the small sample size, which resulted in low statistical power. Also, it was not within the scope of this study to control participants' behavior outside of the laboratory (e.g., food consumption, overall activity, and amount of sleep), which may have impacted study results. It should be noted that strength data were not collected for the postexercise period, alternatively, the time frame before the commencement of either the seated or flotation treatments. Lastly, potential apprehension of participants before entering the flotation tank may have caused interference with the accuracy of data collected. Every participant was inexperienced with flotation REST before this study.

Results of this study indicate that flotation REST seems to have a significant effect on blood lactate. We found a decrease in blood lactate after a 1-hour flotation REST session compared with a 1-hour seated condition, which potentially allows for enhanced muscle recovery. Lowered torque production of the knee extensor muscles was observed after flotation, which may be explained by the lack of sensory stimuli and perhaps concomitant decline in proprioception and decreased motor control. Our data also suggest that individuals suffering from lingering muscle pain may also benefit from flotation REST. Based on this study, DOMS was not alleviated at a quicker rate after flotation. However, the inflammatory response causing pain during DOMS (7) possibly may have been dampened by the absorption of magnesium sulfate ($MgSO_4$) across the skin. Therefore, it appears from this study that flotation REST may be used for acute recovery from strenuous exercise but does not have any significant effect on alleviating DOMS.

Practical Applications

Flotation REST may be used as an alternative method of recovery after strenuous and exhaustive exercise of the knee extensors and flexors by enhancing muscle recovery by decreasing high levels of lactate. Athletes who have experienced micro-injury and who are in an increased state of pain may also find pain alleviation after flotation REST, which was observed in the current study and in several previous studies (12,16,29). The perception of pain may be decreased for several hours after a 1-hour flotation condition or even several months when administered on a consistent basis (29), which may give an athlete the confidence to play in the upcoming game or event. Although it is not recommended to play through a serious injury, which unfortunately is observed on a regular basis in collegiate and professional sport, flotation REST may provide a less risky alternative than other interventions. However, this method of pain relief as a preexercise, or precompetition, agent has not yet been studied and needs to be further investigated as our data suggest that force production immediately after REST treatment may be dampened. Recent literature has also displayed how chronic stress negatively impacts many physiological mechanisms involved in the recovery process (32). Athletes and the normal population may be able to use flotation REST after sustaining musculoskeletal injury to aide in the alleviation of pain and perhaps enhance recovery. This new literature may warrant further investigation regarding the utilization of various relaxation, or stress relieving methods, on the psychological and physiological mechanisms associated with the recovery phase.

Acknowledgments

No funding was provided for this study. The results of the present study do not constitute endorsement of any product involved in this study by the authors or the NSCA.

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