Gallagher et al. (2020) *Int J Res Ex Phys*. 16(1):1-18.

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International Journal of Research in Exercise Physiology

Original Research Article

Stress Inoculation Training and Mental Fatigue

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Abstract

Purpose: The purpose of this study is to examine the effectiveness of stress inoculation training on reducing the effect of mental fatigue on physical performance. **Methods:** Moderately trained runners completed three lab visits: familiarization, pretest, and posttest. During the pre and posttest, all participants completed a 5 km time trial in a mentally fatigued state, induced by watching a video that elicits joy, sadness, and disgust while not showing any emotion. Participants were randomly assigned to the control or experimental group. Both groups were asked to watch a video every day for the 14-day intervention period. The experimental group watched the same emotion-eliciting video as they did during the testing sessions, while the control watched a short nature documentary. **Results:** Nine participants (experimental group n = 5) completed all testing sessions. The experimental group had an average time to completion of 24.65 min and 24.67 min in the pretest and posttest (respectively), while the control group had an average time of 20.35 min and 20.19 min in the pretest and posttest (respectively). No significant differences were found in time to completion, heart rate, lactate, effort, pain, self-rated emotion felt, and difficulty to suppress that emotion (except the difficulty suppressing sadness). However, a large change in self-rated disgust felt and difficulty suppressing disgust was seen in the experimental group from pre to posttest (disgust felt: 63.4 ± 27.7 vs. 31.8 ± 28.8 and difficulty suppressing 57.8 ± 29.8 vs. 27.6 ± 33.4), which was not seen in the control group (disgust felt: 68.5 ± 25.4 vs. 65.8 ± 29.6, difficulty suppressing: 60 ± 30.0 vs. 59.0 ± 24.5). The EMG data collected had large inter and intra-variability and did not correlate with performance metrics. **Conclusion:** There were no negative impacts of the intervention, which indicates the stress inoculation may be a low-risk, low-cost method of improving stress response, but further studies need to be done to show efficacy.

Key Words: Emotional Suppression, Mental Fatigue, Stress Inoculation Training.

Introduction

Over 120 years ago, mental fatigue was first observed in academic settings [1,2]. Mental fatigue (also referred to ego depletion) is caused by a cognitive demanding task and results in a decrease of performance on subsequent cognitive tasks [3–7]. The cause may be due to the brain having finite energy to perform executive functions, such as self-inhibition (i.e., self-control) [3,4,8].

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Simple tasks, such as resisting cookies, suppressing emotional expression while watching movies, and inhibition in a writing task, have been shown to decrease in performance on subsequent cognitive tasks [3,4].

Mental fatigue has multiple implications in physical performance. With the executive function compromised by mental fatigue, performance in skill-based sports, such as darts and free throw shooting, suffers [9–12]. Endurance performance has also been shown to be compromised by mental fatigue. Marcora et al. (2009) showed 90 minutes of an unmatched Stroop task, an inhibition task, reduced time to exhaustion in a cycling task. Likewise, studies done on cycling and running time trial performance after a mentally demanding task have found decreases in performance [13–15]. Wagstaff (2014) showed that emotional suppression decreased subsequent cycling time trial performance. Emotional suppression is of concern for athletes who often encounter situations that require emotional suppression (e.g., press conferences and interaction with competitors).

The mechanism linking mental fatigue and decrements in endurance performance is not completely understood, but the psychobiological model of endurance performance has attempted to explain how mental fatigue affects endurance performance. This model argues that the conscious brain is the main regulator of exercise [17]. Muscle recruitment is determined by a momentary decision based on perceived exertion, motivation, knowledge of remaining distance/duration of the event, knowledge of distance that already has been covered, and previous experiences [17–19]. Therefore, mental fatigue results in fewer muscle fibers recruitment and consequently the pace for the endurance performance is slower.

Avoiding mentally demanding tasks or situations that require emotion regulation is not feasible for athletes. Therefore, it is paramount to find methods to overcome mental fatigue. Examples of such methods include caffeine [20] and inspirational stories [21], but research on these methods is scant. Another method that may provide great benefit is psychological skills training. Psychological skills interventions, including sessions on positive self-talk, goal setting, imagery, and relaxation, have been proven effective in improving performance and are widely used in endurance performances [22]. Another type of psychological skills training is stress inoculation training, which involves repeated exposure to a stressor in a controlled environment so that coping skills can be practiced and refined [23,24]. Stress inoculation training has been shown to improve pain tolerance in athletes [24] and 10 km cycling performance [23]. However, there is limited literature on stress inoculation training in mitigating mental fatigue, despite its possible effectiveness.

The purpose of this study is to examine the efficacy of stress inoculation training on

attenuating the effects of mental fatigue on endurance performance. The hypothesis is that stress inoculation training will decrease the effects of a mentally demanding task on 5 km performance and result in an improved performance via an increase in muscle recruitment. As predicted by the psychobiological model, a second hypothesis is that improvements with stress inoculation training will be due to an increase in muscle recruitment (evident from the EMG).

Methods

Participants

The target population for this study was moderately trained runners. Participants had to be 18 years or older, have at least one year of running-related training experience, run over 20 miles per week, and have competed in at least one race previously. Participants were not allowed to partake if they had suffered an injury in the last month, had unable to run five-kilometers, have any disease or illness that makes physical performance unsafe (based on the American College of Sports Medicine risk stratification), or do not meet the other requirements. The study protocol was approved by the University Institutional Review Board for the Protection of Human Subjects.

Procedures

Participants reported to the lab for three visits: familiarization, pretest, and posttest. There were 14 days between the pre and posttest during which participants completed an at-home intervention. The type of intervention (control or experimental) was randomly assigned.

Familiarization

Informed consent was obtained from all participants. A health questionnaire was used to assess the risk of participation for each subject. Any participant classified as high risk was not allowed to participate in the study. Demographic information, volume, and intensities of training the week before, racing and running experience, injury history, and training history were all collected during the familiarization session.

Participants completed a 15-30 minute run while wearing the BioNomadix to get accustomed to running with the device. Appointments were made for the next sessions. While subjects were aware of all the procedures that were to be done, they were not told the nature of the study, including hypothesis and intervention status, until the completion of the study.

Testing session

Upon arriving at the lab, participants provided the volume and intensities of their training from the previous week. The participants then had 30 minutes to warm-up, change, or complete any other pre-race rituals. At the end of this time, participants were asked to put an H10 Polar heart monitor around their chest. Electromyography (EMG) was used to assess muscle recruitment. A BioNomadix device collected EMG data via a Biopac MP

150 system using the single differential method. Data was initially analyzed by the AcqKnowledge program with data being exported to Microsoft Excel for further analysis. The skin on the right leg was prepared according to the electrode manufacturer (BioPac EL501). Electrodes were placed 2 cm center-to-center distance on the belly of the bicep femoris and rectus femoris with a ground electrode placed on the femoral epicondyle, which was all located via palpation. The bicep femoris and rectus femoris were selected because of their major roles in running locomotion [25], and these muscles have been measured in previous research done on running gait [25,26].

To induce mental fatigue, participants watched a 10-minute video that elicits three different emotions: joy, sadness, and disgust. The joy segment showed videos such as laughing babies. The sad segment contained elements that depict loss and strife. The disgust segment contained scenes from *Fear Factor*, such as diving into cow blood or drinking donkey urine. During the video, participants were asked not to show emotions. Researchers observed participants' facial emotions to ensure they comply with this request. Emotional suppression while watching emotion-eliciting videos has been found to be an effective and ethical way to induce mental fatigue [16,21,27,28].

After the video was finished, the participants rated the emotional response (i.e., 0 being no emotional response, 100 being the most emotion you have felt) and difficulty to suppress that emotion (i.e., 0 being no difficulty in suppressing that emotion, 100 impossible to suppress that emotion) on 100-point Likert scales for each section for a total of six responses.

Next, participants were given 10 minutes to do any more warm-ups and adjustments. A baseline lactate measure was taken using a Lactate Plus meter. Lactate Plus meters have high reliability and validity in analyzing lactate and have been deemed suitable for research [29]. Participants were then asked to do a "sprint stride," defined by an acceleration to top speed and holding top speed for five seconds. EMG data was recorded during this stride to be used for normalization.

After a brief rest, the subject completed the five-kilometer time trial on an indoor track (25 laps). To improve ecological validity, a visible lap count, verbal encouragement, and split times were provided throughout the time trial. Incentive prize money was awarded to the runner with the best age-graded performance (i.e., the highest percentage of the world record in that age division). Splits and time to completion were recorded using a handheld stopwatch. The runners were not be allowed to have their own watch or listen to music. The H10 heart monitor recorded heart rate during the trial and transferred the data via Bluetooth upon completion of the test. EMG was recorded throughout the time trial.

Upon completion of the time trial, lactate was again measured via a small blood drop. Retrospective RPE and perceived pain ranking were collected upon completion of the time trial via CR10 scales (i.e., ranking how much pain/ effort from 0 to 10 with 10 being the possible maximum perception of pain or effort) adapted from Borg[30]. Previous research has suggested that perception of effort and perception of pain are separate measures[31]. In the CR10 for exertion, participants were asked how hard they felt they were working, and in the CR10 for pain, participants were asked how much pain they felt they were in. Participants were then allowed to cool down, and the heart rate and EMG monitors were removed.

The posttest consisted of the same procedures as the pretest. A debriefing form was provided at the completion of the testing procedures, and the researchers conducted a debriefing session, including discussing the nature and hypothesis of the study.

Intervention

The intervention took place over 14 days. Stress inoculation training in a clinical context has been found to be effective when implemented from one week to 14 weeks with sessions lasting upwards of two hours [32–35]. However, even a one-week stress inoculation intervention was shown to be effective in cyclists [23]. A two-week intervention period was used to balance the required length to see effects while reducing drop-out, improving adherence, and minimizing the effects of physical training.

The participants in the treatment group were provided a link to an emotion-eliciting video, the same used in the pre and post measures. The participants in the control group were provided a link to a neutral video (nature documentary). Both groups were informed to watch the video every day. On days they have a run or workout, they were asked to watch it before the workout. The treatment group was to practice suppressing their emotions.

Data analysis

The EMG data was filtered with a bandwidth of 50 Hz- 1 kHz as described in Guidetti et al. (1996). Raw EMG data results in large variations and requires normalization to allow comparisons across individuals and different testing sessions. Traditionally, EMG is normalized to a maximum isometric voluntary contraction using an isokinetic device. The changing length of the muscle and changing viewpoint of the electrode (i.e. different parts of the muscle and new muscles all together will enter and exit the range that the electrode will pick up) make it inappropriate to normalize dynamic movements to maximum voluntary isometric contractions [36,37]. Halaki and Ginn (2012) suggest using a maximum dynamic contraction similar to the contraction being measured. For running studies, a sprint trial prior to a testing session has been used for normalization [26,38–40]. However, all these

studies used peak amplitude during the stance phase of running. This method is problematic in measuring long term muscle recruitment because of the number muscle contractions that occur during a five-kilometer time trial and the required equipment to do biomechanical analysis [26,38,39]. To overcome this shortcoming, root means squared (RMS) summed over a 5s interval during the trial were divided by the RMS over the 5s maximum sprint to arrive at a percentage of maximum recruitment during running activity. Alternatively, the first five-second segment of the time trial was also used to normalize the data, which has been done in cycling research [41]. For both normalization methods, the average percentage of recruitment during the whole test was found.

To our knowledge, no study has validated this method of EMG analysis. The aim of this study is to assess the feasibility and potential issues with the EMG device to assessing muscle recruitment over the course of a self-paced long-distance event. The internal validity of the normalized EMG was assessed by finding correlations to time trial completion time. Inter and intra-variability were also assessed by the coefficient of variance and percent change to establish reliability.

Statistical analyses

The mean and standard deviation were calculated for heart rate, muscle recruitment, time to completion, post-run lactate, effort and pain ratings, the emotion felt and level of difficulty suppressing that emotion while watching the emotional eliciting video (pre and posttest), and scores on each factor on the BMS. A mixed ANOVA was used to examine differences in the time trial, emotional response, and difficulty suppressing emotion across groups and pre and posttest.

Results

A total of 28 people volunteered to be in the study; however, only nine (male n = 4, female n = 5) completed both the pre and posttest (Figure 1). The average age of the participants was 29 years old (SD = 10.12). Participants ran between 20 and 90 miles per week and reported racing twice to 50 times per year. The mean and standard deviation for time trial time, heart rate, lactate, effort, pain, emotions felt, and emotional suppression scores are shown in Table 1.

No significant differences were found in time to completion, heart rate, lactate, effort, pain, self-rated emotion felt, and difficulty to suppress that emotion (Table 2). The only exception was the difficulty suppressing sadness, which was found to have an interaction effect ($F_{(1,7)}$ = 9.184, p = 0.019). However, large mean differences existed between pre and posttest only in the experimental group for the emotion felt and difficulty suppressing that emotion (Figure 2). Individual results were graphed (Figure 3) to further explore the nature of the impact of the intervention. The coefficient of variation indicated that large

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individual variations exist in response to the intervention with some individuals being large responders and others not responding to the intervention.

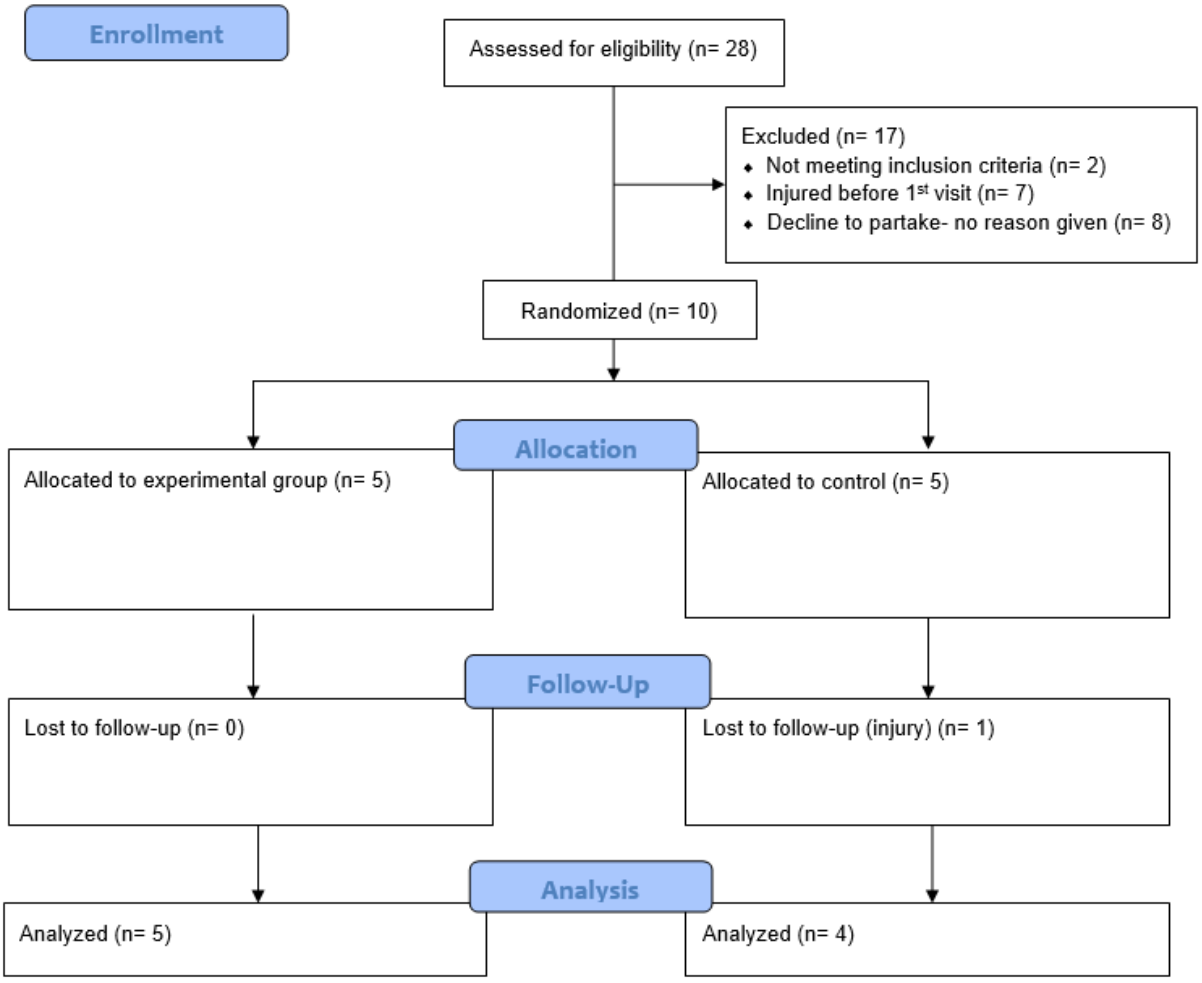

Figure 1: Despite having 28 volunteers, only 9 participants completed all testing sessions.

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Table 1. Descriptive statistics (mean ± standard deviation) for time trial and emotion variables.

	Pretest		Posttest	
	Experimental	**Control**	**Experimental**	**Control**
Time trial (min)	24.65 ± 3.29	20.35 ± 5.26	24.67 ± 3.52	20.19 ± 4.94
Average heart rate (BPM)	170 ± 15	179 ± 5	170 ± 8	180 ± 5
Max heart rate (BPM)	180 ± 16	187 ± 4	178 ± 11	189 ± 5
Post lactate (mmol)	8.60 ± 3.57	11.55 ± 1.63	9.90 ± 3.81	12.95 ± 2.62
Effort	7.6 ± 1.64	9.25 ± 0.5	8.0 ± 1.58	9.0 ± 0.82
Pain	4.70 ± 3.67	6.25 ± 3.59	5.50 ± 3.28	6.75 ± 3.95
Emotion Felt				
Joy	87.6 ± 16.3	53.0 ± 10.2	54.2 ± 45.9	56.3 ± 15.0
Sadness	49.0 ± 26.0	42.8 ± 22.7	28.0 ± 28.4	40.8 ± 28.3
Disgust	63.4 ± 27.7	68.5 ± 25.4	31.8 ± 28.8	65.8 ± 29.6
Difficulty Suppressing				
Joy	91.8 ± 12.4	49.8 ± 17.4	53.0 ± 45.9	39.5 ± 17.5
Sadness	58.6 ± 26.90	24.0 ± 9.1	19.4 ± 20.4	40.0 ± 27.5
Disgust	57.8 ± 29.8	60 ± 30.0	27.6 ± 33.4	59.0 ± 24.5

Table 2. The *p* values for the results of the mixed ANOVA. *denotes significant value with a $p < .05$.

	Within	**Between**	**Interaction**
Time to completion	0.794	0.163	0.724
Average heart rate	0.694	0.173	0.767
Max heart rate	0.952	0.229	0.381
Post lactate	0.142	0.329	0.951
Effort	0.717	0.161	0.145
Pain	0.552	0.542	0.889
Emotion Felt			
Joy	0.204	0.309	0.132
Sad	0.225	0.841	0.308
Disgust	0.083	0.282	0.133
Difficulty Suppressing			
Joy	0.083	0.092	0.277
Sad	0.243	0.579	0.019*
Disgust	0.086	0.359	0.104

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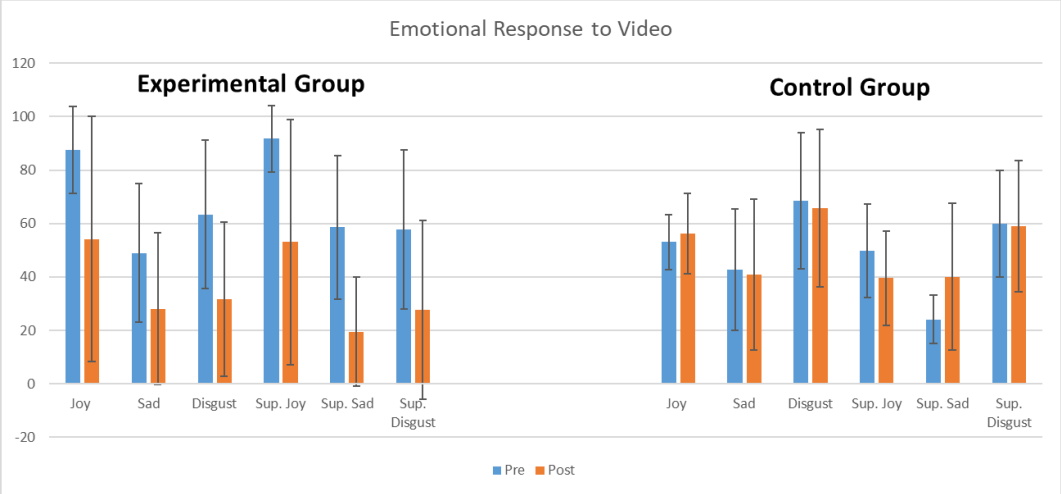
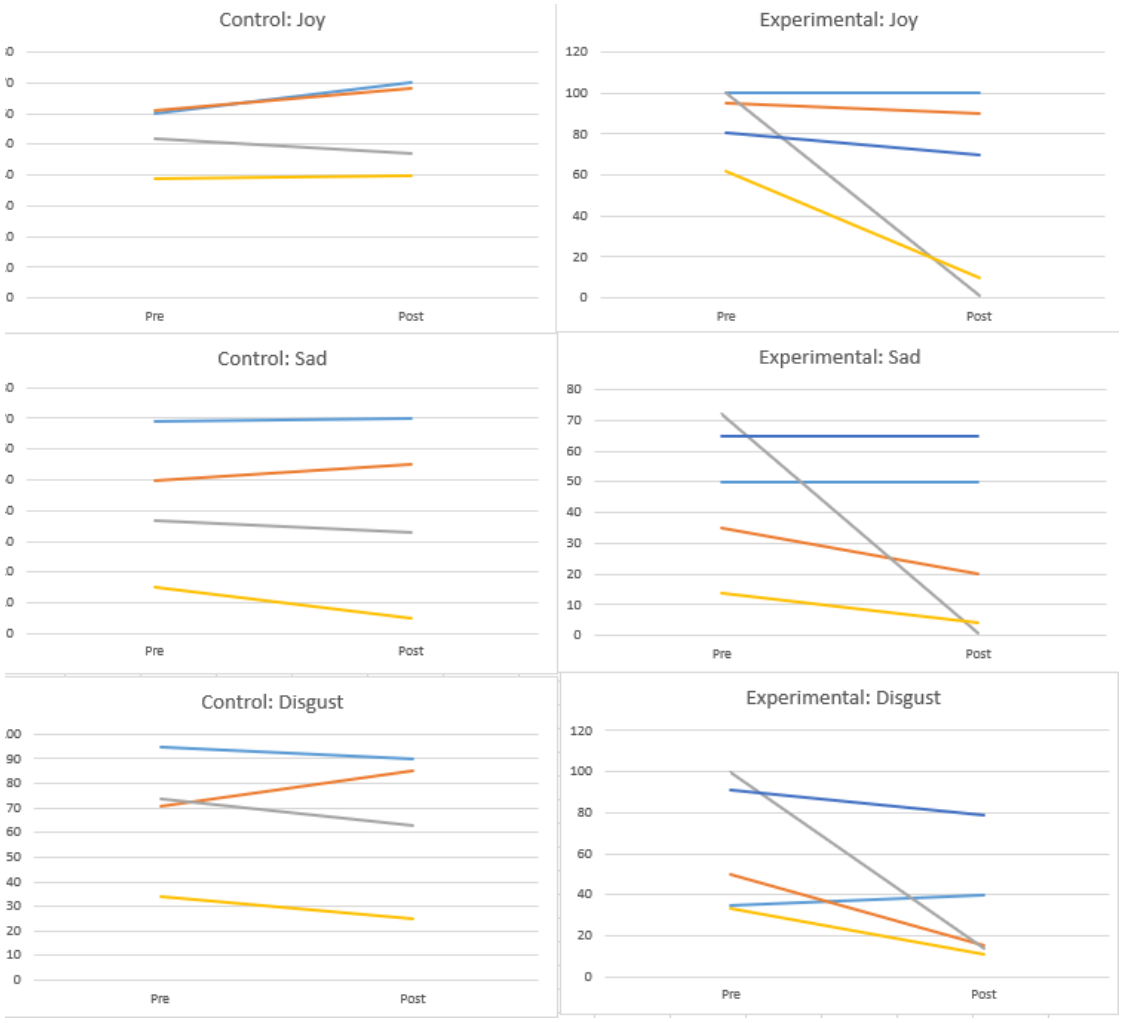


Figure 2: The average ratings of how much of each emotion (joy, sadness, and disgust) and how difficult it was to suppress that emotion (Sup. Joy, Sup. Sad., Sup. Disgust) are shown with the respective standard deviations with the pretest values in blue and posttest values in orange.



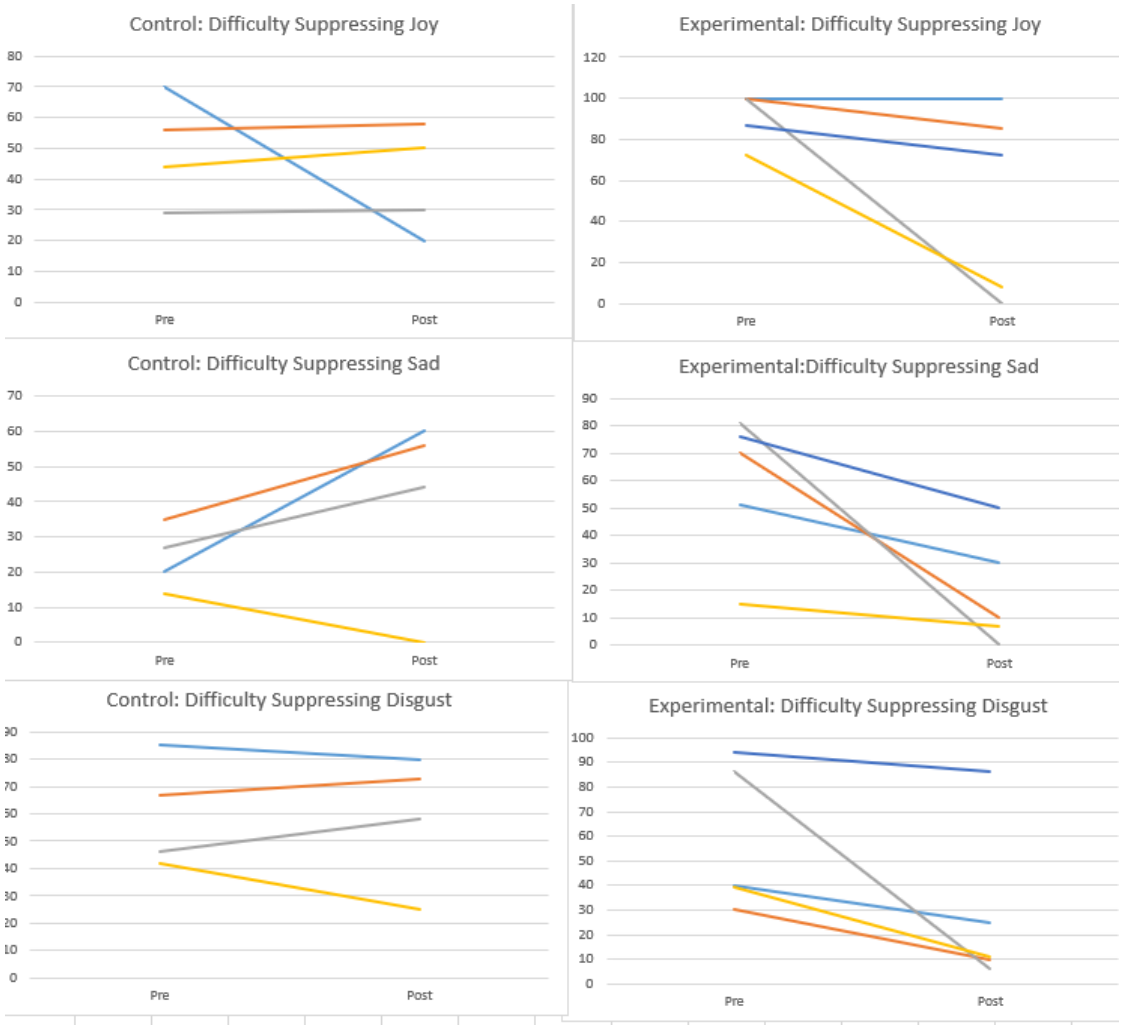


Figure 3: Individual changes for each emotional variable are shown.

For mood, There were no differences between groups for all subscales: anger ($F_{(1,7)}$ = 5.157, p = 0.057), confusion ($F_{(1,7)}$ = 0.002, p = 0.968), depression ($F_{(1,7)}$ = 1.403, p = 0.275), fatigue ($F_{(1,7)}$ = 2.27, p = 0.175), and vigor ($F_{(1,7)}$ = 0.169, p =.693). There were no significant interactions effects found: anger ($F_{(1,7)}$ = 0.194, p = 0.673), confusion ($F_{(1,7)}$ = 2.352, p = 0.169), depression ($F_{(1,7)}$ = 1.221, p = 0.306), fatigue ($F_{(1,7)}$ = 0.26, p =0.876, and vigor ($F_{(1,7)}$ = 0.604, p = 0.463). However, there were significant differences within-subjects: anger ($F_{(1,7)}$ =17.841, p < 0.001), confusion ($F_{(1,7)}$ = 29.393, p =0.004), depression ($F_{(1,7)}$ = 4.978, p = 0.009), and vigor ($F_{(1,7)}$ = 25.982, p < 0.001). However, no within-subject differences existed in fatigue ($F_{(1,7)}$ = 1.357, p = 0.283).

The mean percentage and standard deviation of EMG data normalized to the sprint and the first 5s of the time trial are shown in Table 3. The time trial performance did not correlate with the EMG data from rectus femoris and the

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bicep femoris normalized to the sprint (r = -0.45, p = 0.06; r = -0.41, p = 0.09, respectively (Figure 4). The coefficient of variance for EMG normalized to the sprint were smaller (Quadriceps: *CV* = .57, Hamstring: *CV* = .59) compared to when the EMG is normalized to the first 5s (Quadriceps: *CV* = 1.67, Hamstring: *CV* = 1.26). The average percentage change from pre to posttest was 116% (*SD* = 412.53) and 49.82 % (*SD* = 131.48) for the bicep femoris and rectus femoris, respectively, indicating high intra-subject variability. Individual results for the EMG data are shown in Figure 5.

Table 3. Mean percentages ± standard deviation and the average % change from pre to post-test are shown for both rectus femoris and bicep femoris.

		Mean	Average % Change
Rectus Femoris	**Pre**	40.11 ± 23.98	56.84 ± 134.22
	Post	46.89 ± 26.58	
Bicep Femoris	**Pre**	36.78 ± 17.72	133.49 ± 433.62
	Post	38.78 ± 27.08	

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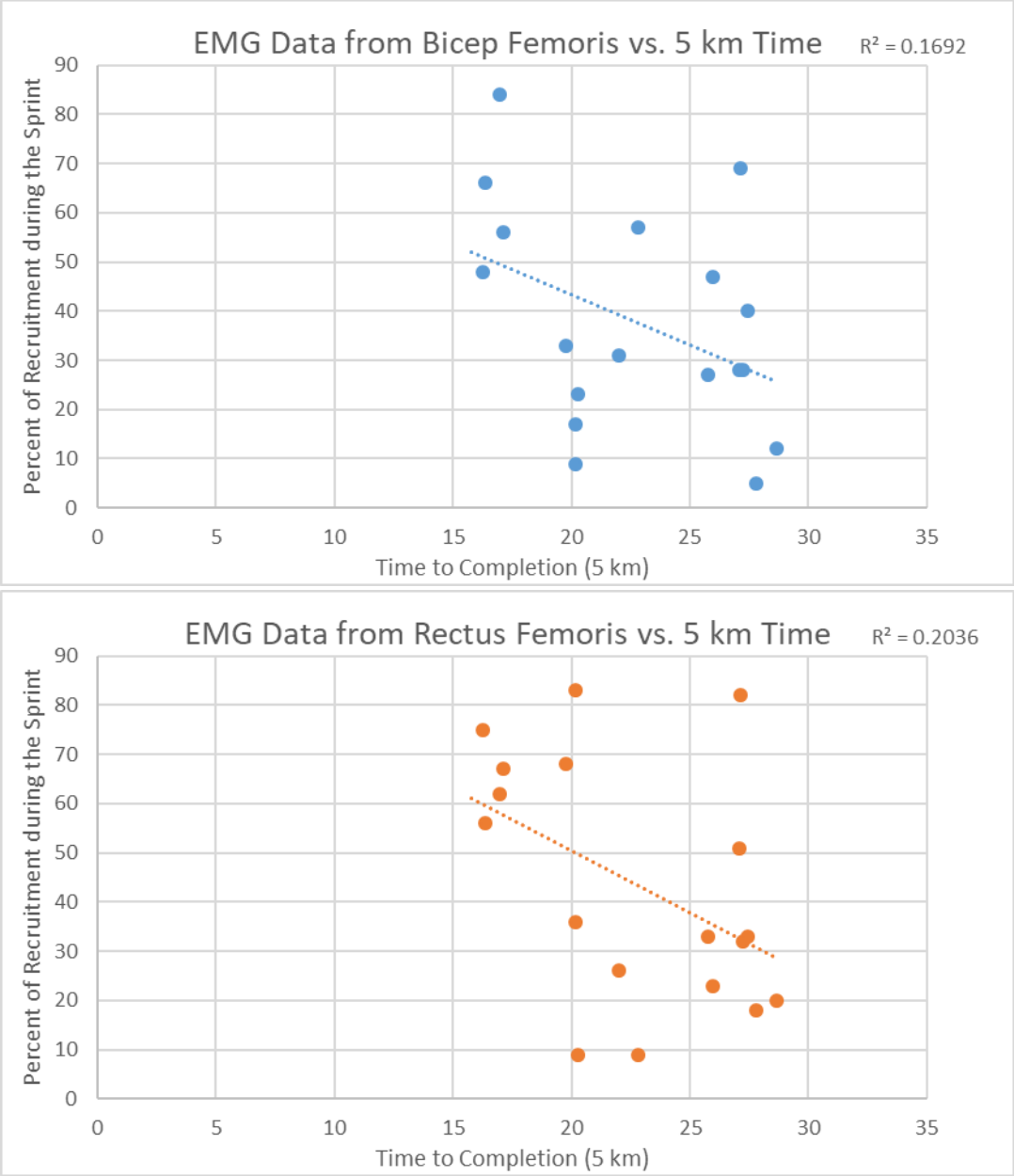

Figure 4: The relationship between EMG (expressed as a percent of sprint) and time to completion in the time trial are shown.

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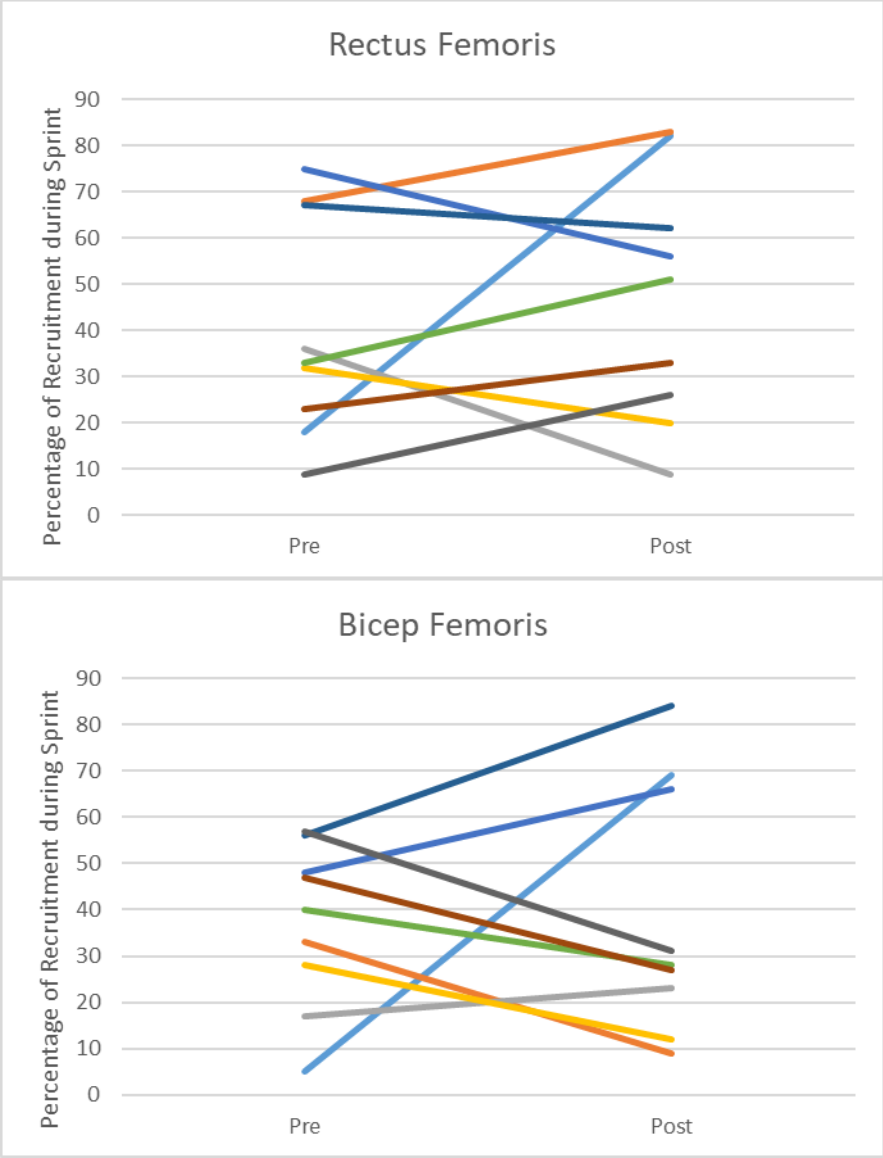

Figure 5: The percentage of recruitment during the sprint for each participant is shown for both the rectus femoris and bicep femoris.

Discussion

This study attempted to determine the effects of stress inoculation training on mental fatigue's impact on a five-kilometer time trial. There were no significant differences in physiological measures and performance measures. In this study, training, nutrition, and sleep among other possible external variables were not controlled, largely in an effort to replicate a real-life setting and due to the difficulty in controlling all variables that could impact performance. Future studies will want to have better control over these external variables to establish better internal validity so that the efficacy or lack thereof can be firmly established. Training centers or teams that train together provide one

possible way to control these external variables.

Self-rated emotional response and difficulty to suppress that emotion while watching the emotion-eliciting video were not significantly impacted by the intervention. Certain participants saw large decreases in emotional response, while others saw no response. It is important to note that the intervention only increased disgust felt (i.e., 35 out of 100 to 40 out of 100) in one participant, while all other participants saw a reduction or no change in disgust. All other emotional variables (i.e., sadness and joy felt, and the difficulty to suppress joy, sadness, and disgust) were reduced or had no change.

A small sample size could be a contributing factor to the lack of significant findings, but the question remains of why certain individuals did not have any response to the intervention. One possible explanation is the length of the intervention. When stress inoculation has been used in reducing phobias, the intervention has been longer in length lasting months and/or has sessions lasting two hours or more with repeated exposures [32–34]. It is plausible that the individuals who did not respond to our intervention would have responded to a longer intervention.

A second explanation is the context of the stimulus. Stress inoculation has been shown to be context specific; stress inoculation is more effective when it mimics the setting of the actual stimulus [34,35]. Since participants watched the video at home, it is plausible that when participants reported to the lab that the context changed reducing the effectiveness of the intervention. However, the intervention length, instead of context, was more likely the cause of the non-response in certain individuals. Self-reported emotional response during the training period (i.e., how much each emotion was felt on each individual day while watching the video) did not change for the individuals who did not respond to the intervention, indicating that at no point did they experience a reduction in the emotion felt. The context of stress inoculation training will be an important factor to consider in future research and in the application (i.e., coaches will want to replicate the stressors and the setting they will be presented as close to the real scenario as possible).

Future research may want to examine the length required to obtain results from stress inoculation training. One possible research path could be to use an unmatched Stroop task (inhibition task) repeatedly across multiple testing sessions and measure response times and mistakes to measure improvements from training. Using neuroimaging to examine changes in the cingulate cortex in future research could also be of benefit. The cingulate cortex is the area of the brain that is responsible for inhibition (e.g., suppressing emotion or completing an unmatched Stroop task) and for making the cost to benefit analysis in

physical performance [42,43]. It is likely responsible for the link of impaired physical performance and mental fatigue [43–45]. Practical research has shown that elite cyclists have superior inhibitory control, indicating that high-level performance may require or lead to changes in the cingulate cortex [46]. Research done on monkeys has identified a protein, called Stargazin, that leads to adaptations that occur in the cingulate cortex with repeated exposure to an emotional stressor [44].

The emotion-eliciting video had a clear and consist impact on mood with the intervention having no effect on this impact. Research has suggested that having an "iceberg" profile of moods, defined as a higher score on vigor and lower scores on fatigue, anger, depression, and confusion, promotes better endurance performance [47]. From this standpoint, the emotion-eliciting video negatively impacted mood by decreasing vigor and increasing the anger, confusion, and depression. The stress inoculation training did not prevent these unfavorable mood changes. Further research is needed to confirm that altering the profile of moods negatively impacts performance, and if so, possible ways to mitigate this impact.

This study provides guidance on EMG usage in similar studies going forth. First, normalizing to the start of the time trial, instead of the sprint, is problematic when comparing across testing sessions and subjects. By normalizing to the first 5s of a trial, the data set is depending on pacing strategy (i.e., larger recruitment in the first 5s will lower percentages of the rest of the trial, and lower recruitment in the first 5s will do the opposite). The coefficient of variance reflects this issue with large variations when normalized to the first 5s. Only research interested in examining recruitment within a trial, such as Duc et al. (2005), should use this normalization technique. Normalizing to a sprint before the testing session itself resulted in less variance.

However, neither method correlated with performance. Normalizing to sprint produced problematic intra-subject variability with large changes between tests, and some values were extremely low (e.g., 6%) compared to previous literature [40]. Excessive distance from the BioPac is likely the cause of this issue. A 200m track better replicates a race by being self-paced as compared to a treadmill. However, the 200m track provides a set up that results in an excessive distance (>10m as recommended by the manufacturer) from the Bionomadix transmitter and the BioPac. Research looking to replicate a real-life scenario and getting EMG data will want to carefully balance the set-up to ensure that the devices are well within range or (when available) use a recording device that can be transferred later (e.g., logger device).

To further validate using 5s RMS as a measure of muscle recruitment over longer periods of time, research will need to be

done that can directly match pace or power with the EMG magnitudes. A treadmill or a tracking device (e.g., GPS) could be used to determine pace over 5s increments and directly compare to the EMG magnitude to pace or power over that same 5s interval. A complex relationship may exist between muscle activation and pace because of breaking forces and external factors that may influence the effectiveness of the muscle recruitment contributing to pace [25,26]. However, RMS over 5s intervals may provide a novel way to overcome analyzing thousands of contractions across a time trial. In addition, this method allows for the measurement of the combination of the frequency of the contraction and the power of those contractions. A more frequent recruitment counterbalances smaller magnitude contractions (i.e., more frequent small strides), while larger magnitude contraction will counterbalance less frequent recruitment (i.e., less frequent larger strides). This method allows direct comparison between the overall recruitment and the power/pace outputted.

Conclusion

While this study found no significant findings of improvements in performance or a decrease in emotional response due to the intervention, there were no negative impacts of the intervention, which indicates the stress inoculation may be a low risk, low-cost method of improving stress response. These findings suggest that responses to this type of intervention are individualistic. Previous research suggests that the length and the context of the intervention may also play a role in the efficacy of a program. Therefore, coaches and athletes will want to incorporate simulations of "game day stressors" early in the training to accrue maximum benefits.

Research done on the mechanism of adaption to stress inoculation must work to control external variables to preserve internal validity. However, application research and application of the program itself will need to recognize and preserve these external variables to ensure the application is truly meaningful and has external validity. Ultimately, if stress inoculation training is to be effective, like all aspects of training, it will have to work harmoniously with, and not against, all other variables in an athlete's training regime to reach maximum performance.

Acknowledgements

We would like to thank T.J. Nicholson and Bretta Gonzalez for their work in the data collection process. We would also like to thank the Northland chapter of the ACSM for providing funding (student innovation grant).

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References

1. Mosso A. *Fatigue*. Longmans, Green; 1896.
2. Winch WH. Mental fatigue in day school children as measured by immediate memory: Part I. *J Educ Psychol*. 1912;3(1):18-28. doi:http://dx.doi.org.ezproxy.mnsu.edu/10.1037/h0070728

3. Baumeister RF, Bratslavsky E, Muraven M, Tice DM. Ego depletion: Is the active self a limited resource? *J Pers Soc Psychol*. 1998;74(5):1252-1265. doi:http://dx.doi.org/10.1037/0022-3514.74.5.1252
4. Baumeister RF, Muraven M, Tice DM. Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Soc Cogn*. 2000;18(2):130-150. doi:10.1521/soco.2000.18.2.130
5. Marcora. Counterpoint: Afferent feedback from fatigued locomotor muscles is not an important determinant of endurance exercise performance. *J Appl Physiol*. 2010;108(2):454-456. doi:10.1152/japplphysiol.00976.2009a
6. Marcora, Bosio A, de Morree HM. Locomotor muscle fatigue increases cardiorespiratory responses and reduces performance during intense cycling exercise independently from metabolic stress. *Am J Physiol-Regul Integr Comp Physiol*. 2008;294(3):R874-R883. doi:10.1152/ajpregu.00678.2007
7. Marcora, Staiano W, Manning V. Mental fatigue impairs physical performance in humans. *J Appl Physiol*. 2009;106(3):857-864. doi:10.1152/japplphysiol.91324.2008
8. Muraven M, Baumeister RF. Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychol Bull*. 2000;126(2):247-259. doi:10.1037/0033-2909.126.2.247
9. Englert, Bertrams A. Anxiety, ego depletion, and sports performance. *J Sport Exerc Psychol*. 2012;34(5):580-599. doi:10.1123/jsep.34.5.580
10. Englert, Bertrams A, Furley P, Oudejans RRD. Is ego depletion associated with increased distractibility? Results from a basketball free throw task. *Psychol Sport Exerc*. 2015;18:26-31. doi:10.1016/j.psychsport.2014.12.001
11. Furley P, Bertrams A, Englert C, Delphia A. Ego depletion, attentional control, and decision making in sport. *Psychol Sport Exerc*. 2013;14(6):900-904. doi:10.1016/j.psychsport.2013.08.006
12. McEwan D, Ginis KAM, Bray SR. The effects of depleted self-control strength on skill-based task performance. *J Sport Exerc Psychol*. 2013;35(3):239-249. doi:10.1123/jsep.35.3.239
13. Englert, Wolff W. Ego depletion and persistent performance in a cycling task. *Int J Sport Psychol*. 2015;46:137-151.
14. MacMahon C, Schücker L, Hagemann N, Strauss B. Cognitive fatigue effects on physical performance during running. *J Sport Exerc Psychol*. 2014;36(4):375-381. doi:10.1123/jsep.2013-0249
15. Pageaux B, Lepers R, Dietz KC, Marcora SM. Response inhibition impairs subsequent self-paced endurance performance. *Eur J Appl Physiol*. 2014;114(5):1095-1105. doi:10.1007/s00421-014-2838-5
16. Wagstaff CRD. Emotion regulation and sport performance. *J Sport Exerc Psychol*. 2014;36(4):401-412. doi:10.1123/jsep.2013-0257
17. Marcora. Do we really need a central governor to explain brain regulation of exercise performance? *Eur J Appl Physiol*. 2008;104(5):929. doi:10.1007/s00421-008-0818-3
18. Pageaux B. The psychobiological model of endurance performance: An effort-based decision-making theory to explain self-paced endurance performance. *Sports Med Auckl*. 2014;44(9):1319-1320.
19. Smirmaul BPC, Dantas JL, Nakamura FY, Pereira G. The psychobiological model: A new explanation to intensity regulation and (in)tolerance in endurance exercise. *Rev Bras Educ Física E Esporte*. 2013;27(2):333-340. doi:10.1590/S1807-55092013005000008
20. Azevedo R, Silva-Cavalcante MD, Gualano B, Lima-Silva AE, Bertuzzi R. Effects of caffeine ingestion on endurance performance in mentally fatigued individuals. *Eur J Appl Physiol*. 2016;116(11):2293-2303. doi:10.1007/s00421-016-3483-y
21. Martijn C, Alberts HJEM, Merckelbach H, Havermans R, Huijts A, de Vries NK. Overcoming ego depletion: The influence of exemplar priming on self-control performance. *Eur J Soc Psychol*. 2007;37(2):231-238. doi:10.1002/ejsp.350
22. Thelwell RC, Greenlees IA. Developing competitive endurance performance using mental skills training. *Sport Psychol*. 2003;17(3):318-337. doi:10.1123/tsp.17.3.318
23. Kress J, Schroeder J, Potteiger J a., Haub M. The use of psychological skills training to increase 10 KM cycling performance: an exploratory investigation. *Int Sports J*. 1999;3(2):44-54.
24. Whitmarsh BG, Alderman RB. Role of psychological skills training in increasing athletic pain tolerance. *Sport Psychol*. 1993;7(4):388-399. doi:10.1123/tsp.7.4.388
25. Gazendam MGJ, Hof AL. Averaged EMG profiles in jogging and running at different speeds. *Gait Posture*. 2007;25(4):604-614. doi:10.1016/j.gaitpost.2006.06.013
26. Guidetti L, Rivellini G, Figura F. EMG patterns during running: Intra- and inter-individual variability. *J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol*. 1996;6(1):37-48.
27. Gross JJ, Levenson RW. Hiding feelings: The acute effects of inhibiting negative and positive emotion. *J Abnorm Psychol*. 1997;106(1):95-103. doi:http://dx.doi.org/10.1037/0021-843X.106.1.95
28. Martijn C, Tenbült P, Merckelbach H, Dreezens E, de Vries NK. Getting a grip on ourselves: Challenging expectancies about loss of energy after self-control. *Soc*

Cogn. 2002;20(6):441-460. doi:10.1521/soco.20.6.441.22978

29. Baldari C, Bonavolontà V, Emerenziani GP, Gallotta MC, Silva AJ, Guidetti L. Accuracy, reliability, linearity of Accutrend and Lactate Pro versus EBIO plus analyzer. *Eur J Appl Physiol*. 2009;107(1):105-111. doi:10.1007/s00421-009-1107-5
30. Borg G. *Borg's Perceived Exertion and Pain Scales*. Human Kinetics; 1998.
31. Marcora S. Perception of effort during exercise is independent of afferent feedback from skeletal muscles, heart, and lungs. *J Appl Physiol*. 2009;106(6):2060-2062. doi:10.1152/japplphysiol.90378.2008
32. Bouton ME, Swartzentruber D. Sources of relapse after extinction in Pavlovian and instrumental learning. *Clin Psychol Rev*. 1991;11(2):123-140. doi:10.1016/0272-7358(91)90091-8
33. de Jong PJ, Peters M, Vanderhallen I. Disgust and disgust sensitivity in spider phobia: Facial EMG in response to spider and oral disgust imagery. *J Anxiety Disord*. 2002;16(5):477-493. doi:10.1016/S0887-6185(02)00167-6
34. Rowe MK, Craske MG. Effects of varied-stimulus exposure training on fear reduction and return of fear. *Behav Res Ther*. 1998;36(7):719-734. doi:10.1016/S0005-7967(97)10017-1
35. Viar-Paxton MA, Olatunji BO. Context effects on habituation to disgust-relevant stimuli. *Behav Modif*. 2012;36(5):705-722. doi:10.1177/0145445512446189
36. Halaki M, Ginn K. Normalization of EMG signals: To normalize or not to normalize and what to normalize to? *Comput Intell Electromyogr Anal - Perspect Curr Appl Future Chall*. Published online 2012. doi:10.5772/49957
37. Mirka G. The quantification of EMG normalization error. *Ergonomics*. 1991;34(3):343-352. doi:10.1080/00140139108967318
38. Albertus-Kajee Y, Tucker R, Derman W, Lamberts RP, Lambert MI. Alternative methods of normalising EMG during running. *J Electromyogr Kinesiol*. 2011;21(4):579-586. doi:10.1016/j.jelekin.2011.03.009
39. Besier TF, Lloyd DG, Ackland TR. Muscle activation strategies at the knee during running and cutting maneuvers. *Med Sci Sports Exerc*. 2003;35(1):119-127. doi:10.1097/00005768-200301000-00019
40. Chuang TD, Acker SM. Comparing functional dynamic normalization methods to maximal voluntary isometric contractions for lower limb EMG from walking, cycling and running. *J Electromyogr Kinesiol*. 2019;44:86-93. doi:10.1016/j.jelekin.2018.11.014
41. Duc S, Betik A-C, Grappe F. EMG activity does not change during a time trial in competitive cyclists. *Int J Sports Med*. 2005;26(2):145-150. doi:10.1055/s-2004-817922
42. Boksem MAS, Tops M. Mental fatigue: Costs and benefits. *Brain Res Rev*. 2008;59(1):125-139. doi:10.1016/j.brainresrev.2008.07.001
43. Lorist MM, Boksem MAS, Ridderinkhof KR. Impaired cognitive control and reduced cingulate activity during mental fatigue. *Cogn Brain Res*. 2005;24(2):199-205. doi:10.1016/j.cogbrainres.2005.01.018
44. Lee AG, Capanzana R, Brockhurst J, et al. Learning to cope with stress modulates anterior cingulate cortex stargazin expression in monkeys and mice. *Neurobiol Learn Mem*. 2016;131:95-100. doi:10.1016/j.nlm.2016.03.015
45. Schweimer J, Hauber W. Involvement of the rat anterior cingulate cortex in control of instrumental responses guided by reward expectancy. *Learn Mem*. 2005;12(3):334-342. doi:10.1101/lm.90605
46. Martin K, Staiano W, Menaspà P, et al. Superior inhibitory control and resistance to mental fatigue in professional road cyclists. *PLOS ONE*. 2016;11(7):e0159907. doi:10.1371/journal.pone.0159907
47. Morgan WP, O'Connor PJ, Ellickson KA, Bradley PW. Personality structure, mood states, and performance in elite male distance runners. *Int J Sport Psychol*. 1988;19(4):247-263.