THE INFLUENCE OF CONCURRENT EXERCISE ORDER ON POSITIVE AND NEGATIVE AFFECT

by

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A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Science in
Kinesiology

Charlotte

2023

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ABSTRACT

REMY EMETO. The Influence of Concurrent Exercise Order on Positive and Negative Affect. (Under the direction of DR. JOSEPH S. MARINO)

Introduction: Understanding affective responses to exercise is necessary to increase adherence and reduce barriers to participation. This study will be the first to determine the relationship between positive and negative affect to blood lactate during and following exercise. We will test the hypotheses that exercise order influences affect and negative affect scores are associated with higher intra-session and post session blood lactate levels. **Purpose:** The purpose of this study is to determine whether the order in which aerobic and resistance training is performed influences affective responses. **Methods:** Each participant was screened for exclusion criteria and completed the physical activity readiness questionnaire (PARQ+). Participants then completed 3 lab visits. **Results:** Blood lactate levels increased in response to exercise and remained elevated 30 minutes post. When RT was performed first, participants experienced a greater sense of positive well-being prior to the start of the session. Psychological distress decreased 30 minutes post exercise compared to pre-exercise values. Fatigue remains elevated 30 minutes post exercise for both groups. We see a decrease in Tranquility for the RTAT group when comparing timepoints. We also see an increase in tranquility for the RTAT group when comparing timepoints. **Conclusions:** Exercise regardless of order does influence affective responses and will lead to an increase in blood lactate levels.

ACKNOWLEDGMENTS

I would like to give a special thank you to Dr. Marino for taking me on as a student. He allowed me to utilize his study as my thesis project. I would like to acknowledge that his grant helped pay for the materials associated with this study. I would also like to give a special thank you to my thesis committee: Dr. Moore-Harrison and Dr. Howden for their time and help. I would further like to thank Dr. Marino for providing me with some financial support from his grant. Furthermore, I would also like to thank Samantha Brooks, who was also a co-investigator of this study for her time, help, support and dedication. I would further like to acknowledge and thank the Department of Applied Physiology, Health and Clinical Sciences for accepting me as a graduate student in their master's program.

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LIST OF ABBREVIATIONS

1RM	1-rep max
10RM	10-rep max
30Post	30 minutes post exercise
ACSM	American College of Sports Medicine
ANOVA	analysis of variance
AT	aerobic training
ATRT	aerobic training followed by resistance training
BDNF	brain-derived neurotrophic factor
BL	blood lactate
CDC	Centers for Disease Control and Prevention
GXT	graded exercise test
HRmax	heart rate max
HRR	heart rate reserve
iPost	immediately post exercise
MPH	miles per hour
PAAS	physical activity affect scale
PARQ+	physical activity readiness questionnaire
RPE	ratings of perceived exertion
RT	resistance training
RTAT	resistance training followed by aerobic training
SEES	subjective exercise experiences scale

INTRODUCTION

Exercise requires physical exertion in hopes of sustaining or improving health and fitness. There are many physical and psychological benefits of exercise especially related to preventing chronic diseases. For example, benefits of exercise include body weight management, blood pressure reduction, improved bone health, increased muscular strength, increased function capacity, reduced dementia risk, improved cognition, and better mental health. Literature supports that by participating in an exercise routine significantly reduces risk for chronic diseases and improves treatment outcomes [2]. For these reasons, exercise programming has become highly recommended and offered in many clinical settings and for various chronic health conditions. Although the benefits of exercise, especially regarding chronic diseases, are well known, there is still a high prevalence of physical inactivity. The World Health Organization suggests adults perform at least 150 minutes (about 2 and a half hours) of moderately intense exercise every week or a minimum of 75 minutes of vigorously intense activity each week [3]. According to the CDC exercise data from 2020, the percentage of adults aged 18 and over who met the 2018 guidelines for aerobic exercise was 53.3%. Furthermore, the percentage of adults aged 18 and over who met the 2018 exercise guidelines for both aerobic and muscle-strengthening exercise was 23.2% [4]. Understanding common barriers to exercise and determining ways to overcome them may help increase engagement. Commonly cited reasons for lack of exercise are lack of time, energy, and motivation [5]. The CDC also identified lack of social support, fear of injury, lack of skill, excessive costs, and accessibility as barriers [6].

A better understanding of the affective response to exercise is a necessary step toward finding ways to increase adherence and reduce barriers to participation. Affective response to exercise refers to the positive and negative emotions an individual may feel during and following an exercise session [7]. Engagement in aerobic and strength exercise is correlated with an increase in positive affect [8, 9]. However, intensity and volume of exercise may influence affective responses [10]. In fact, the complexity of the relationship between affect and exercise is based on several variables such as exercise scenario, intensity, and individual physical activity levels [11] [12]. The main influence of affective responses during exercise is the intensity at which physical activity is executed. According to the dual model theory [11], the lactate threshold acts as an indicator of exercise intensity [13-16]. This means that at prescribed intensities below or around lactate threshold, there is a positive affective response. However, when exercising at or above lactate threshold, the affective response is less pleasant resulting in negative affect [13, 14, 16, 17]. Negative affect is one of the first few signs that changes are occurring in energy regulation and body balance [7]. Furthermore, there have been no studies that have looked at the effects of concurrent aerobic and strength exercises, or the order in which they are performed, on affective responses. The purpose of this study is to determine whether the order in which aerobic and strength exercise is performed influences affective responses. Furthermore, this study will be the first to determine the relationship between positive and negative affect to blood lactate during and following exercise. Specifically, we will test the hypotheses that exercise order influences affect and negative affect scores are associated with higher intra-session and post session blood lactate levels.

LITERATURE REVIEW

1. **Affect**

Understanding affective responses such as mental health, psychological well-being, and psychological health has rendered many terms such as humor, emotion, and affect [18]. Understanding what affect means and how it applies to exercise is necessary to know what mood and emotion mean [7]. Affect is thought to be the underlying foundation of responses such as positive or negative, pleasant or unpleasant as well as emotions and moods [11, 19]. Emotion is described as a complex reaction pattern that consists of experiential, behavioral and physiological components. Emotions are how individuals handle matters or situations they find significant. Mood is an affective state. As opposed to emotions, moods are less specific, less intense and are least likely to be provoked [7]. Moods are also described as having positive or negative valence. Unlike emotions and moods, affect consists of a basic description of psychological responses and can be considered basic and fundamental. Therefore, affect provides us with the idea that all emotions are affective responses, but not all affective responses are emotions [11, 20].

The analysis of affective responses can occur categorically or dimensionally. The categorical aspect places affective responses in different categories such as anger, fear, sadness, disgust, happiness, love, and pride [20]. The dimensional aspect states that affective responses are interrelated, and their relationships can be supported by those dimensions. Both aspects of affective responses have advantages and limitations, the dimensional aspect has a broader perspective which confirms the attribution of affect and provides a “blueprint” of the affective responses that offers a detailed purview for analysis of affect in exercise [11, 20]. The dimensional aspect allows the exercise-induced affective responses and changes to be recorded [11, 20, 21].

2. Measuring Affect

Measuring affect can be performed by using dimensional models [22]. Certain scales are used to measure affective perceived intensity of affect and/or arousal. For example, The Feeling Scale measures affective responses from +5 (“very good”) to −5 (“very bad”) [23]. Its purpose is to determine the correlation of pleasure and displeasure to exercise. The Felt Arousal Scale is used to measure perceived activation [24]; ranging from low activation [18] to high activation [22]. High activation can be described as excitement, anxiety, or anger while low activation can be described as relaxation, boredom, or tranquility.

The circumplex model measures affect via a two-dimensional model, which involves affective responses such as pleasure-displeasure and perceived activation such as arousal [22, 25]. The circumplex model helps avoid associating and/or affect with terms such as anxiety, depression, and various mood descriptions and to provide a basis for affect responses in exercise [26].

In the circumplex model, the horizontal dimension represents pleasure-displeasure, and the vertical dimension represents arousal. Affective responses are split into four quadrants: quadrant 1 is associated with high arousal and displeasure. The terms associated with this quadrant include tension, nervousness, distress. Quadrant 2 is associated with high arousal and pleasure. The terms associated with this quadrant include energy, excitement, vigor. Quadrant 3 is associated with low arousal and displeasure. The terms associated with this quadrant include fatigue, boredom, tiredness. Quadrant 4 is associated with low arousal and pleasure. The terms associated with this quadrant include tranquility, relaxation, calmness [21, 22, 26]. Studies have concluded that measuring affective responses in exercise and the factors that may influence this relationship are of importance because they may help to minimize barriers to exercise [27-29].

3. Affective Responses to exercise

The correlation between exercise and affective response is not simple to analyze and has many aspects [11]. Although studies relate exercise to affect as a single and simplistic occurrence, there is intricacy between these factors. This intricacy is dependent on affective responses in their correlation with related variables, such as exercise scenario, exercise intensity, and differing physical activity levels amongst individuals [11, 12]. These factors can alter affective responses.

Affective responses have provided evidence that negative affect is one of the first signs of changes in energy regulation and body balance [30, 31]. Studies suggest that afferent signals are linked to affective responses [32]. This hypothesis proposes that changes between aerobic and anaerobic metabolism would coincide with unpleasant affective responses [32].

An important influencer of affective responses during exercise is intensity [33]. The dual model theory states that [11], lactate threshold is an indicator of exercise intensity [13-16], which means that, at certain intensities, affective responses will be predominantly positive. During exercise at lactate threshold, the affective response is less pleasant and possibly negative. An important aspect of intensities is variability of affective responses between individuals with differing physical activity levels, in whom exercise can cause various outcomes of affective responses of pleasure. However, above lactate threshold, there is not much variability, and, typically, a decline in pleasure occurs [16].

It is thought that pleasure and well-being are among the most convincing reasons for adherence in an exercise program, rather than the knowledge of health benefits of exercise [34]. The idea of exercise providing pleasure can be useful to an individual, whereas individuals may associate discomfort with damage or danger [14]. The variability in affective responses may be an indicator that exercise can cause pleasure or displeasure. However, whenever individuals respond similarly, it is thought that the situation is one that has consistent implications for change [14].

3a. Exercise intensity and affective responses

Exercise intensity is an important factor [28, 35]. Performing 30 minutes of moderate-intensity exercise, i.e., 64–76% of maximum heart rate (HRmax) (at least 5 days a week), or 20 minutes of vigorous intensity, i.e., 77–95% of HRmax (3 days a week), is the minimum recommendations proposed by the American College of Sports Medicine (ACSM) for health-related physiological benefits. Studies have also shown that exercise intensity is one of the main influencers of affective exercise response [21, 36-38].

Vandoni [35] demonstrated that vigorous exercise causes lower affective responses in comparison to moderate exercise. Alves [39] observed weight training in elderly women, performed at 35% of 1 repetition maximum (1RM) elicited higher affective pleasure responses compared to higher intensities such as 50% and 70% 1RM. Follador [40] observed that, even in moderately active adults, high-intensity still elicited less pleasure responses, and maximal or supramaximal intensities were highly associated with displeasure and negative impact on exercise program adherence.

When measuring affective responses, the task response should be prioritized over the post-exercise response [41]. Studies have shown that, when exercise intensity exceeds lactate threshold, there is a decrease in affective response and this change has a greater impact on future adherence than the affective responses obtained after exercise [41, 42]. However, medium- to long-term studies have not investigated exercise adherence. Parfitt [38] studied the 6-month effect on physical fitness and affective responses of sedentary people after an 8-week intervention program. Three groups participated: a control group, a group that exercised in lower intensity, and a group in higher intensity. Their results showed that training at a lower intensity exhibited more positive affective responses in relation to the control and higher intensity groups. Perri [43], who aimed to observe the relationship between intensity, frequency, and adherence to exercise over 6 months, revealed that moderate intensity exercise produced greater exercise adherence (66 vs. 58%) than exercise prescription of higher intensity.

3b. Affective responses and self-selected intensity

Self-selected intensity is when the participant chooses the preferred intensity [44]. For beginners, exercise at intensities above lactate threshold may cause displeasure and changes in exercise intensity toward self-selected intensities. In this sense, beginners seek lower intensities and greater affective pleasure responses [45].

Motives related to exercise have been investigated. To better understand the factors leading to the permanence, or dropout, of beginners of exercise programs, the hedonic theory and the self-determination theory have been utilized to understand self-selected exercise [46-48]. The hedonic theory of motivation suggests that when one experiences pleasure, joy, or fun, one will seek to repeat that activity. However, if the situation induces displeasure, pain, or discomfort, the chance of adherence is lower [47, 49]. The self-determination theory prioritizes autonomy. Its emphasis is on providing a sense of empowerment and can promote pleasure and greater intrinsic motivation [46, 49, 50]. The sense of empowerment and pleasure forms the basis of self-selected exercise.

Behavioral theories are linked to the physiology of effort. Lower-intensity activities and feelings of displeasure are inversely related [44]. However, the duration of activity may also be related to displeasure, with shorter duration exercises eliciting greater adherence than very long activities [49, 51].

Self-selected intensity exercise has been recommended as a way to improve exercise participation and adherence in sedentary people [19, 44]. Studies have shown that inactive individuals who self-select an exercise intensity according to ACSM parameters, associated more with lower intensities and positive affective responses [37, 38, 52]. Although some studies have revealed that affective responses are more dependent on exercise intensity [53, 54], other studies revealed that prescribed exercise at the same intensity as self-selected intensity, results in different affective responses. Hamlyn-Williams [55] revealed that aerobic exercise lowers perceptual responses and affective responses are higher during self-selected intensities. Da Silva [56] also revealed similar results with regards to resistance training, in majority of the exercises used had lower perceptual responses, and all exercises showed higher affective responses when utilizing self-selected intensity.

Self-selected intensity was shown to be better for providing similar or more pleasurable affective responses than imposed intensity exercises [57]. Freitas [37], who compared walking exercise programs at self-selected and imposed intensities (10% above lactate threshold) over 12 weeks (about 3 months) of training, the results showed that self-selected intensities induced more pleasurable affective responses, where certain physiological responses were lower than in the imposed intensity protocol. Additionally, walking at a self-selected intensity was enough to improve maximal oxygen uptake. Yang [58] concluded that both self-selected and prescribed intensities improved physical activity levels and positive affect responses as well as reduced waist circumference, systolic and diastolic blood pressure. However, the self-selected intensity was still more favorable to the increase of positive affect than the prescribed intensity.

3c. Influence of exercise order on affective responses

Bellezza et al revealed a significant effect for condition, time, and condition × time regarding the Feeling and Felt Arousal Scale [59]. In the large to small exercise order, there was no change in Feeling Scale with time; however, there was a change in Felt Arousal Scale [59]. In the small to large exercise order, there was a significant effect for time in both Feeling Scale and Felt Arousal Scale [59]. Like aerobic exercise [13, 17], immediately after exercise there was an increase in affective pleasure responses and arousal. This finding occurred regardless of exercise order. However, in the small to large exercise condition, affective responses were more positive during exercise, after overhead press, and at 10 minutes postexercise. Studies revealed that affective responses during exercise may be important to exercise adherence [13, 17, 60, 61]

Few studies have examined affect as a result of resistance exercise. Arent and colleagues [62] found that affective responses were more positive after moderate-intensities compared with low- and high-intensities. The study also examined affect during the exercise session. No previous study has examined affective responses during resistance exercise. Furthermore, moderate intensity such as 70% of 10-repetition maximum [10RM], elicited the highest and most favorable affective pleasure responses compared with 40% and 100% of 10RM [62].

3d. Negative affect and blood lactate

A limitation of these studies [62] was that they did not look at the role of blood lactate concentration and its influence on affect. Previous studies have shown a strong correlation between lactic acid and RPE (rating of perceived exertion or how hard one feels like their body is working) [63], but due to limited research the effects of blood lactate concentration on affective responses are unknown. The amount of lactate produced can be somewhat dependent on exercise order and the number of repetitions completed. If lactate responses are similar between the two exercise sequences, this may provide a partial explanation for the maintenance of RPE seen by Simao and colleagues [64, 65].The results indicate that there were no significant correlations ($p > 0.05$) between blood lactate and affective responses at any time point and in either exercise order [59].

4. Conclusion

Understanding affect from a multifaceted viewpoint provides a greater outlook of the relationship between exercise and affect. Although affect is thought to be complex, exercise intensity seems to be one of the main influencers of affective responses in exercise. Nonetheless, there have been no studies that have looked at the effects of concurrent aerobic and strength exercise, or the order in which they are performed, on affective responses. This study's purpose is to determine if exercise order influences positive and negative affective responses and if there is a relationship between those affective responses and blood lactate levels. Furthermore, we will test the hypothesis that exercise order does influence exercise affect and negative affect scores are associated with higher intra-session and post-session blood lactate levels.

METHODS

Participants

All procedures were approved by the Institutional Review Board prior to participant recruitment. Participants were recruited via campuswide email. Prior to participation, each participant was screened for exclusion criteria, including: Participants must have accumulated less than 150 minutes (about 2 and a half hours) of moderate physical activity per week. They must have engaged in resistance training an average of 1 day per week or less. They must have been physically capable of running on a treadmill. They must have been able to tolerate 15 to 20 minutes of moderate intensity physical activity, such as running or cycling at 60 to 85% of age predicted heart rate. They must have been free from musculoskeletal injury within the past 6 months. They must have never been told by a medical professional to avoid moderate to vigorous exercise. They must have been able to understand written and verbal instruction provided using English language. They cannot have used tobacco, e-cig, or vaping in the past 12 months. They cannot have been taking any non-steroidal anti-inflammatory drugs. Participants completed the physical activity readiness questionnaire (PARQ+) prior to coming into the lab, which determined if there were any cardio-respiratory contraindications to exercise. If the participant answered “yes” to any of the PARQ+ questions, he or she would not have been able to continue in the study. Participants who met any of the exclusion criteria were not consented to participate. Participants read and signed the informed consent prior to the first visit.

Procedures

Participants completed 3 lab visits. *Visit 1*: Participants reviewed and signed the informed consent. Demographic information was collected followed by body composition via BodPod. Participants then sat in a quiet room for 5 minutes to establish resting heart rate, which was used to calculate 85% heart rate reserve (HRR). Participants then completed a graded exercise test until 85% HRR was reached, or the participant requested to stop. Participants were then given 5 minutes to recover prior to determination of the 10-repetition maximum (10RM) for the goblet squat, barbell bench press, Romanian deadlift, and seated cable row. Lastly, participants were familiarized with the finger stick blood lactate measurement. Visit 2: Participants were randomly given an exercise order. Participants then completed pre-exercise Physical Activity Affect Scale (PAAS) and Subjective Exercise Experience Scale (SEES) surveys which were administered electronically. Participants then had their blood lactate collected and measured pre-exercise. Participants then performed a 5-minute general warm up on a treadmill at 3mph. Participants then performed either aerobic exercise or resistance exercise depending on the random order. Participants then had their intra session blood lactate collected and measured. Participants then completed intra session PAAS and SEES surveys electronically. Participants then performed either aerobic exercise or resistance exercise depending on random order. Participants then had blood lactate collected and measured immediately post (iPost) exercise. Participants then rested for 30 minutes (30post) post exercise and had their blood lactate collected and measured. Participants then completed PAAS and SEES surveys 30post exercise electronically.

Familiarization Session

Participants reported to the exercise physiology lab. Formal screening began by reviewing the informed consent and verifying musculoskeletal medical history. The familiarization session included a treadmill graded exercise test (GXT) to 85% heart rate reserve (HRR), a finger stick blood lactate measurement and familiarization of the strength training exercises. The purpose of the GXT was to determine the workloads for the aerobic exercise portion of the study. Participants warmed up for 3 minutes at 3.0 miles per hour (mph), without holding the handrail. The test began at 3 mph and increase by 0.2 mph and 2% grade incline every 2 minutes until the participant requested to stop or reached 85%HRR, whichever came first [66]. Heart rate was recorded every minute. RPE was recorded during the transition of each workload, using the modified Borg RPE scale (0Nothing to 10Maximal Exertion). Blood lactate was measured to familiarize the participant with the process. Strength training exercises were completed in the following order: dumbbell goblet squat, barbell bench press , Romanian deadlift and seated cable row [67]. For each exercise, the participant was instructed on technique and then a 10-repetition maximum (10RM) was determined using standard procedures [68].

Experimental Procedures

Aerobic Training

Participants completed two exercise trials, randomly assigned, and separated into 1 week. The trials differed in their order of aerobic and strength training exercise. During one trial, participants performed aerobic training followed by strength training and during the second trial, resistance training followed by aerobic training. Each trial began with a 5-minute treadmill warm up at 3mph. The AT exercise session included 5 x 5-minute intervals which corresponded with an intensity of 50% to 70% HRR as determined by the GXT. Participants performed 2 minutes at 50% and 3 minutes at 70% HRR during each interval.

Resistance Training

During the RT exercise session, participants completed as many repetitions as possible, for 3 sets of each exercise, using their predetermined 10RM with one minute of rest in between each set. There will be 3 minutes of recovery during the transition between aerobic training followed by resistance training, and 90 seconds (about 1 and a half minutes) rest between sets of resistance training.

Experimental Procedures

Blood Lactate

Blood lactate (BL) was analyzed immediately prior to exercise (Pre), after completion of the first modality of a session (Intra), immediately after completion of both modalities (iPost), and after 30 minutes of recovery (30Post). The finger of the nondominant hand was cleaned with ethanol and wiped dry. A lancet was used to poke the finger and a drop of blood was collected with the lactate meter. A gauze pad was used to apply pressure in order to stop the bleeding (1 minute), followed by a band aide.

Positive and Negative Affect.

Pre, Intra, iPost, and 30Post, participants completed the Physical Activity Affect Scale (PAAS) [69], and Subjective Exercise Experiences Scale (SEES) [70]. The PAAS is a 12-item scale used to measure feeling in response to exercise from 0 (Do Not Feel) to 4 (Feel Very Strongly). The PAAS defined four constructs: positive affect, negative affect, fatigue and tranquility. The SEES is a 12-item scale that also assessed feelings in response to exercise, from 1 (Not at all) to 7 (Very Much so). This SEES defined three constructs: Positive well-being, Psychological Distress, and Fatigue

Statistical Analysis

The effect of exercise order on blood lactate, well-being, psychological distress, and affective feelings, were determined using a repeated measures two-way ANOVA. When significant differences were found, a post-hoc test was used to identify main effects and interactions. The alpha level for all statistical analyses was p < 0.05.

Results

16 college aged students (18-24 years) participated in this study. Of those 16 subjects, 9 were male subjects and 7 were female subjects. Affective responses were assessed pre-exercise, intra-exercise, immediately post exercise and 30 minutes post exercise. Blood lactate was also assessed during those same timepoints.

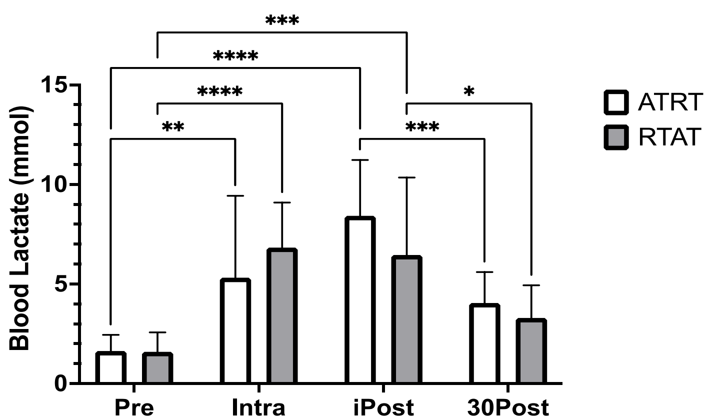

Figure 1. Blood lactate levels were assessed for both groups at pre-exercise, intra-exercise, immediately post exercise and 30 minutes post exercise timepoints. Blood lactate levels increased in response to exercise and remained elevated 30 minutes post exercise. *; p<0.05, **; p,0.005, ***; p<0.0005, and ****; p<0.0001 as indicated by brackets.

As expected, blood lactate levels increased in response to moderate to vigorous exercise (figure 1). Intra –session blood lactate levels increased compared to pre-exercise, regardless of which modality was first. Blood lactate levels remained elevated through 30 minutes post exercise, with no difference between groups at any time point.

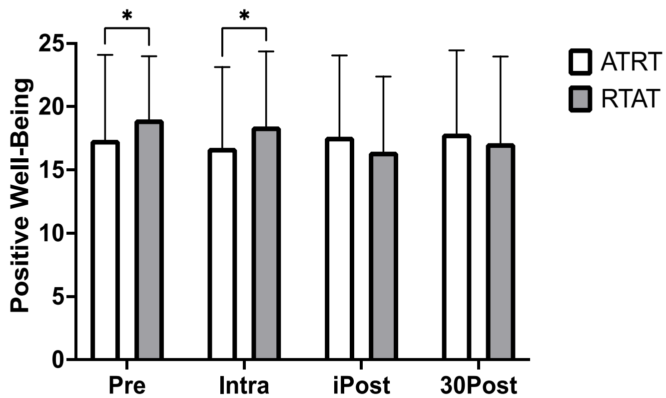

Figure 2. Feelings of Positive well-Being were assessed via SEES for both groups at pre-exercise, intra-exercise, immediately post exercise and 30 minutes post exercise timepoints. A higher score is indicative of higher feelings of positive well-being and lower feelings of psychological distress. Feelings of positive well-being increased in response to exercise during pre and intra timepoints in the RTAT compared to the ATRT group. *; p<0.05 between groups.

When RT was performed first, participants experienced a greater sense of positive well-being prior to the start of the session (figure 2). This indicates that advanced knowledge of the order in which exercise will be performed may influence one's feelings leading into that session and starting with RT may be preferred. Interestingly, the increase in positive well-being persisted to the intra-session time point in the RTAT group and was no longer significantly different following the AT portion of the session. This may indicate that RT increased positive well-being to a greater extent than AT. Of note, when RT was performed second, positive well-being was not significantly different between groups. This could be due to the demands of the AT training session.

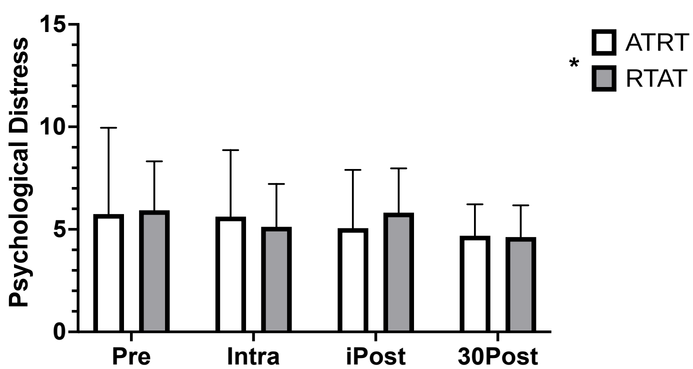

Figure 3. Feelings of psychological distress were assessed via SEES for both groups at pre-exercise, intra-exercise, immediately post exercise and 30 minutes post exercise timepoints. A higher score is indicative of higher feelings of psychological distress. Psychological distress decreased in response to moderate to vigorous exercise independently of the order of exercise. *; p<0.05, main effect for time.

The order in which exercise was performed did not alter psychological distress (figure 3). However, regardless of exercise order, psychological distress decreased 30 post exercise compared to pre-exercise values. This indicates that the combination of RT and AT, independent of order, reduces psychological distress and could be an effective tool in the management of stress in college aged individuals.

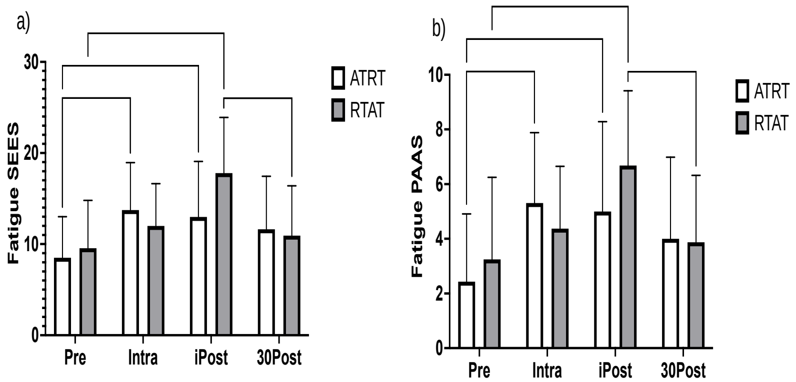

Figure 4. Feelings of Fatigue were assessed via SEES (a) and PAAS (b) at pre-exercise, intra-exercise, immediately post exercise and 30 minutes post exercise timepoints. A higher score was indicative of higher levels of fatigue. Both scales showed similar changes in feelings of fatigue throughout exercise. **; p<.005, ***; p<0.0005, ****; p<0.0001 as indicated by brackets.

When comparing fatigue regarding both the SEES and the PAAS (figure 4), fatigue remains elevated 30 minutes post exercise for both groups. There is also an increase in fatigue in response to exercise regardless of order that is seen in both graphs. The only difference between both graphs is that there was statistical significance for fatigue amongst both groups immediately post exercise meaning that exercise order did have an influence during that timepoint.

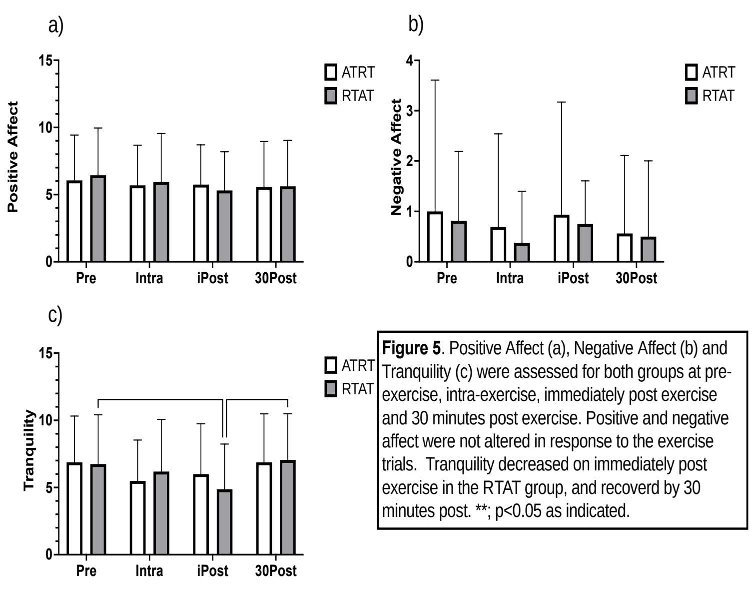

Figure 5. Positive Affect (a), Negative Affect (b) and Tranquility (c) were assessed for both groups at pre-exercise, intra-exercise, immediately post exercise and 30 minutes post exercise. Positive and negative affect were not altered in response to the exercise trials. Tranquility decreased on immediately post exercise in the RTAT group, and recoverd by 30 minutes post. **; p<0.05 as indicated.

There are no differences or statistical significance via modality or timepoint (figure 5). Therefore, exercise order or timepoint does not influence positive affect. There is no statistical significance for negative affect for either group at either timepoint. Therefore, exercise order does not influence negative affect. Overall, there was little to no difference for tranquility when comparing groups. We see a decrease in Tranquility for the RTAT group when comparing pre and iPost. We also see an increase in tranquility for the RTAT group when comparing iPost and 30post. This means that tranquility is most influenced by the RTAT group and with rest tranquility will return to baseline.

Discussion

Elevated blood lactate levels are a normal physiological response to moderate to vigorous exercise and not a symptom of a disease [71-73]. When a subject exhibits an increase in blood lactate during exercise, it could be due to an increase in lactate production and release from muscle, a decrease in lactate uptake and removal or a larger increase in production and release when compared to uptake and removal [74]. During moderate exercise, blood lactate may differ slightly from resting levels. However, the flux of lactate may be many times greater when compared to resting levels [74]. It must also be taken into consideration that a person showing physiological increases in blood lactate may have impaired lactate removal or uptake and/or increased lactate production or release [74]. Differences in lactate threshold and blood lactate between trained and untrained individuals have been examined. Results show that untrained individuals will exhibit lower lactate thresholds and higher blood lactate levels [74]. This relates to our study, as all participants were untrained individuals, we see that in response to moderate exercise, blood lactate levels increased significantly for both exercise order groups.

Research reveals that exercise can elicit a significant reduction in psychological distress from pre-exercise to post-exercise which is also consistent with the results of this study [70]. When looking back at figure 3, we see that there was a decrease in psychological distress in response to exercise independent of order with a main effect for time. It also reveals that exercise can significantly influence psychological responses in terms of decreasing psychological distress and increasing positive well-being which is consistent with the results in this study as well [70]. Brains of deceased depressed individuals were examined; reduced levels of brain-derived neurotrophic factor (BDNF) were present in the hippocampus and cortex compared to the brains of healthy individuals [75]. The reduced BDNF levels in depression can be mediated by taking antidepressant medications [76]. However, exercise shows a similar influence by causing a temporary increase in the concentration of BDNF in peripheral blood [77]. Increased neurogenesis, which can also positively influence depressive symptoms can be induced by exercise [78]. The inflammatory serotonin hypothesis can also explain the positive effects of physical activity on feelings of psychological distress and positive well-being. According to that theory, moderate exercise has an anti-inflammatory effect by controlling the variations in the immune response associated with feelings of depression [79]. The transient hypo-frontality theory is another theory used to explain the increased psychological effects of exercise due to increased neuronal activity in the motor and sensory cortex and brain regions that are responsible for autonomic regulation [80]. Studies also revealed that when exercise was compared to other psychological distress reducing activities, reduction in psychological distress was significantly greater when mediated with exercise [81].

Studies have revealed that brain catecholamines are involved in the onset of fatigue during exercise [82]. Evidence also reveals that the noradrenergic neurotransmitter system speeds up central fatigue, this finding coexists with a faster rate of increase in RPE [82]. Brain neurotransmission during exercise is also suggested to have an influence on mental fatigue [82]. Results from a study revealed that acute aerobic exercise results in increases in physical exhaustion in sedentary older and younger adults which is similar to the results in this study [83]. The correlation between physical exhaustion reported during exercise and postexercise self-efficacy revealed that participants reporting greater fatigue during exercise felt less efficacious after exercise [83]. Another study revealed that exercise effects on feelings of fatigue were not significant [84]. Overall, more research is needed to further examine the effects of exercise on feelings of fatigue [84].

An acute bout of moderate intensity exercise produced more positive and fewer negative states [85]. In-task and post-task affective responses to exercise were measured. Individuals who experienced greater improvements in positive affect and tranquility in response to exercise were more likely to continue adherence [41]. This study further revealed that tranquility decreased during exercise which is consistent with our results but significantly increased past baseline post-exercise [41]. This type of relationship is expected as the tranquility subscale of the PAAS is related to increased perceptions of arousal [86]. Therefore, it is expected that tranquility would decrease during exercise, but increase once the arousing stimulus (exercise) has stopped [41]. On average, participants reported increases in positive affect and decreases in negative affect and tranquility over time. However, these effects tapered off as exercise intensity increased [41]. Feelings of tranquility were also assessed during a combination of low-intensity exercises (walking) and meditation. The results revealed that tranquility increased significantly during the meditation portion of the protocol which could be similar to the 30 minutes of rest post exercise in this study [87].

Conclusions

Much of the research today has never examined the influence of performing both resistance training and aerobic training in the same session on affective responses nor has any of the research examined its influence on blood lactate levels. Our study was the first to do so. Nonetheless, we can conclude that exercise regardless of order does influence affective responses and will lead to an increase in blood lactate levels. This is consistent with our results as we see positive well-being increased in response to exercise while psychological distress decreased following the session. Blood lactate levels also increased due to exercise and remained elevated 30 minutes following. Feelings of tranquility decreased during exercise but returned to baseline with rest. More research is needed: 1. to examine gender differences and their influence on affective responses; 2. To examine the influence exercise order has on fatigue as well as differences between SEES and PAAS and their subscales; 3. The influence of blood lactate levels on affective responses; 4. Most research only examined the effects of aerobic exercise on affective responses. Therefore, more research is needed to examine the effects of resistance training alone on affective responses.

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