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EXERCISE IN THE DARK: THE EFFECT OF AMBIENT LIGHT INTENSITY ON THE SUBJECTIVE EXERCISE EXPERIENCE

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ABSTRACT

Exercise is a feasible way to reduce all-cause mortality, yet participation rates are paradoxically low. A growing trend of exercise classes in the dark has been anecdotally reported as a way to increase exercise participation by removing the element of comparison. The purpose of this study was to investigate the effect of ambient light intensity on the subjective exercise experience. Specifically, the effect of ambient light levels on social physique anxiety and affective responses was measured during group cycling exercise in two different lighting conditions. It was hypothesized that social physique anxiety (SPA) would be lower when group cycling exercising in the dark compared to standard room lighting. The secondary hypothesis was that introverts would report higher pleasure exercising in the dark compared to extroverts. Five participants performed 20 minutes of self-paced cycling exercise on a stationary bike as a group in a standard room lighting condition (~180 Lux) and a darkness condition (~0 lux). State SPA, affective valence, and arousal were measured before and after the cycling exercises. There were no significant effects of lighting condition on any of the outcome variables. Extraversion had a negative correlation with the light condition and positive correlation with the dark condition, although both of these were nonsignificant. All five participants reported preferring the darkness exercise than the standard light exercise. To the best of the author's knowledge, this is the first study to evaluate the phenomenon of exercising in the dark on social physique anxiety.

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CHAPTER 1

INTRODUCTION

Exercise is a prominent way to reduce all-cause mortality. Aerobic exercise has significant physical and mental health benefits (Garber et al., 2011). Yet, a small percentage of the U.S. population meets the minimum weekly guidelines to achieve health benefits (Abildso et al., 2023). Cognitive approaches (e.g., education) to change exercise behavior yield effect sizes ranging from zero to small (Ekkekakis, 2017). Alternatively, hedonic theories suggest that affective responses to exercise may have a stronger influence on promoting and maintaining exercise behavior. Accumulating evidence supports a strong association between the subjective exercise experience and subsequent exercise behavior (Lee et al., 2016).

As the Body Mass Index (BMI) of the US adult population continues to increase, people's evaluation of their physical self in the presence of others can cause additional distress in the context of exercising, namely social physique anxiety (SPA), which can be a significant barrier to exercise participation and adherence. This thesis explores a novel way to reduce SPA and improve affective responses to exercise in group settings by modifying the ambient light in the exercising environment and consequently eliminating visual evaluation cues.

CHAPTER 2

REVIEW OF LITERATURE

Social Physique Anxiety

A barrier to exercise participation is social physique anxiety (SPA), which is defined as the anxiety experienced when one believes others are negatively evaluating their physique in a social setting, such as a group exercise class (Focht & Hausenblaus, 2003; Hart et al., 1989). People who score high on SPA may avoid activities where their physique may be displayed, which often occurs during group exercise. For both males and females, those who more frequently compare their physiques to others often have higher levels of SPA (McCreary & Saucer, 2007).

Much of the available literature on SPA has evaluated the phenomenon in women because they are more likely to experience it than males, consistently reporting higher SPA scores compared to men (Hagger et al., 2014; Hausenblas et al., 2004; McLester et al., 2018; Strong et al., 2006; Zartaloudi et al., 2023). Women with higher levels of SPA are more likely to exercise privately (Spink, 1992) and favor outfits that de-emphasize their physiques (Crawford & Eklund, 1994). Two environmental predictors of social physique anxiety in women are the presence of males and mirrors. Kruisselbrink et al. (2004) showed that women's feelings of SPA increased in an all-male setting compared to an all-female and mixed-sex setting in a hypothetical exercise class. A more recent study by Driediger et al. (2017) found that in physical therapy clinics, women reporting greater SPA scores preferred the presence of fewer male patients in the clinic.

The presence of mirrors in an exercise setting can also have a negative impact on the exercise experience. In females who score high on SPA, the presence of mirrors significantly reduces their exercise self-efficacy (Katula, 1998). Additionally, mirrors have been shown to increase state anxiety (Focht & Hausenblas, 2003, 2004) and social anxiety (Gammage et al., 2004) in females. For sedentary women, the presence of mirrors has also been shown to negatively impact emotional states (Martin-Ginis et al., 2003). Frayeh and Lewis (2018) found that active (>150 min/week/of MVPA) college females who participated in a yoga session with mirrors reported higher SPAscores than participants in the condition without mirrors. These studies suggest that for low-fit or sedentary females, mirrors may intensify body self-awareness, an effect that is magnified in those with SPA. In contrast, Katula and McAuley (2001) reported that in highly active females, mirrors increased self-efficacy when exercising. The authors concluded that the participants used the mirrors to monitor their proper exercise techniques, which may explain the increase in self-efficacy. Since the majority of the US adult population is sedentary, the presence of mirrors and their effect on body self-consciousness is detrimental overall.

In men, SPA is associated with bodybuilding and muscle dysmorphia, a variant of body dysmorphic disorder (Dobersek & Eklund, 2017; Grieves et al., 2008). Body dysmorphic disorder is a psychological condition where an individual is preoccupied with real or perceived defects in their physical appearance (Bjornsson et al., 2010). Muscle dysmorphia, colloquially known as “bigorexia,” is a variant of body dysmorphic disorder where the individual is preoccupied with the notion that their physique is insufficiently muscular. Muscle dysmorphia can occur concurrently with SPA in males (Tod, Edwards,

& Cranswick, 2016). Zheng et al. (2021) found that college males with muscle dysmorphia reported significantly higher SPA scores, as SPA mediated the relationship between muscle dysmorphia and body-checking behavior, a behavior that involves an individual constantly checking their physique in the mirror. However, Despain (2017) found no difference in exercise self-efficacy and body self-consciousness in males who exercised in groups either with or without mirrors in the room. It is worth noting this was an unpublished master's thesis, and is the only apparent article assessing this phenomenon. A systematic review by Mitchell et al. (2017) reported that male bodybuilders were more likely to experience symptoms of muscle dysmorphia compared to recreational resistance trainers, with significant associations between SPA and muscle dysmorphia for both. Experienced bodybuilders (≥2 years of training) had lower SPA scores compared to inexperienced (<2 years of training) bodybuilders (Hurst et al., 2000). Younger bodybuilders (18-27) are more likely to experience both muscle dysmorphia and SPA compared to older bodybuilders (≥28) (Duran & Öz, 2021).

Overall, it may benefit those with SPA or body dysmorphic disorder to avoid mirrors and crowded spaces when exercising. Alternatively, the effects of mirrors and viewing other people in direct line of sight could be eliminated by reducing the ambient lighting and consequently can be reduced to make it harder for individuals to see themselves or others.

Social Physique Anxiety Is Often Higher in Younger Populations

Research indicates that SPA is higher in younger populations than older populations. In an early study, McAuley (1995) reported that adults aged 45-54

experienced greater SPA than participants aged 54 and older. Similarly, Treasure et al. (1998) found a significant negative correlation between SPA and age, with older participants (>45) attending more sessions and exhibiting lower SPA than younger participants (<45). Additionally, Vandever (2001) also found that younger women (31-50 yrs) had significantly higher SPA than older women. In a study by Hagger and colleagues (2010), SPA was significantly higher in younger age groups compared to the oldest age group (18 vs 12-14 yrs), with males showing higher SPA in younger age groups (12-13 and 15 yrs) than older age groups (16-18 yrs). In a subsequent study, Hagger and colleagues (2014) reported that boys aged 11-12 years old had significantly higher SPA than other age groups, while girls aged 11-12 years old and 15-16 years old had lower SPA than any other age group. However, Frederick & Morrison (1996) noted no significant relationship between SPA and age. At the same time, women in their study reported significantly higher SPA overall, and those with higher SPA were more likely to have higher body weight and exercise for extrinsic reasons. Overall, these studies suggest a trend of higher SPA in younger populations across different age and gender groups.

Social Physique Anxiety and Physical Activity Level

Correlations between SPA and physical activity are often non-significant (Crawford & Eklund, 1994; Chu et al., 2008; Portman et al., 2018), likely because of the phenomenon where SPA can serve as either motivation or a deterrent to exercise participation (Portman et al., 2018; Hausenblaus et al., 2004). Individuals high in SPA may avoid public exercise settings to avoid scrutiny (Hart et al., 1989), or may exercise more frequently to change their bodies to become more idealistic (Sabiston et al., 2007).

However, Strong et al. (2006) reported that gender modified the relationship between weight management and SPA. Women with higher SPA scored lower on weight management subscale of the Exercise Motivation-Inventory-2, indicating they were less motivated to exercise for weight management. The opposite was observed in men: men with high SPA score higher on the weight management subscale, indicating they were more motivated to exercise for weight management. This relationship is supported by Zheng et al. (2021) who found that male college students reported higher weekly exercise frequencies the higher in SPA they were.

The Relationship Between SPA and BMI

Reports on the relationship between SPA and BMI are somewhat inconsistent, with different studies reporting different correlation coefficients between the two variables. Some studies report nonsignificant relationships between SPA and BMI. Haase & Prapavessis (1998) found a nonsignificant negative correlation between SPA and BMI. The findings of Yaman (2017) support these results. Vandever (2001) reported a nonsignificant positive correlation between SPA and BMI in younger (31-50 yrs) females and older (51+) females, although, SPA scores were greater by BMI class in this study. Aston (2018) reported a significant negative correlation between SPA and BMI, although a multiple regression analysis showed this relationship was not statistically significant.

Conversely, other research has demonstrated a significant relationship between BMI and SPA. In one of the first studies of this phenomenon, Treasure et al. (1998) found that BMI had a significant positive correlation with SPA scores. SPA had a negative correlation with adherence to a 12-week walking program, although BMI itself did not

have a significant correlation with adherence. Zartaloudia et al. (2023) reported that increases in BMI were associated with increases in SPA score. Tsartsapakis et al. (2023) found a significant small correlation between SPA and BMI. McLester et al. (2018) found that individuals with BMI >25 kg/m^2 had significantly greater SPA scores than individuals with normal weight (<24.9 kg/m^2). Auster-Gussman, Crim, and Mann (2021) found that SPA mediates the relationship between self-reported BMI and exercise frequency. Self-reported BMI significantly correlated with SPA, which significantly correlated with exercise frequency. Individuals reporting higher SPA scores were more likely to report public gyms as hostile (i.e., "feelings of judgment from other gym-goers.") This relationship has also been found in young girls, with significant correlations between self-reported and measured BMI reported in females aged 11-22 yrs (Gay et al., 2009). Regarding the relationship between SPA with body fat percentage, evidence suggests a medium to strong association (McAuley et al., 1995; Treasure, 1998; Yaman et al., 2017). Overall, these studies suggest SPA has a general positive correlation with BMI.

Extraversion-Introversion

SPA may be influenced by personality traits, as preference for group settings has been linked to specific personality types. The Five-Factor Model of personality proposes five main personality traits: extraversion, openness to experience, conscientiousness, neuroticism, and agreeableness (McCrae & John, 1992). Three systematic reviews have examined the relationship between the "Big Five" personality traits and physical activity levels (Rhodes & Smith, 2006; Wilson & Dishman, 2015; Sutin et al., 2016). These

reviews demonstrate that while openness, conscientiousness, and neuroticism predict physical activity behavior, extraversion has the strongest correlation with physical activity levels.

Extraversion-introversion is a trait representing how social one tends to be. (Widiger et al., 2018). The relationship between extraversion and physical activity levels is positive, indicating that people who engage in more physical activity tend to be extroverts. This relationship is also stronger with moderate-to-vigorous exercise intensities than with mild-to-moderate exercise intensities, indicating that extroverts tend to prefer higher-intensity exercise compared to introverts (Wilson & Dishman, 2015).

Extroverts, individuals who score high in extraversion, tend to prefer to exercise in groups, while introverts, individuals who score low in extraversion, tend to prefer to exercise alone (Rhodes & Smith, 2006; Newsome et al., 2021). Early research showed that while baseline arousal levels were the same regardless of trait status, extroverts had lower arousal responses to stimuli, meaning they were less sensitive to sensory stimulation (Stelmack, 1990; Sato, 2007). Additional evidence supports the finding that extroverts tend to seek out more novelty and excitement to achieve a higher, more pleasurable level of arousal (Jawinsiki et al., 2021). extroverts also tend to engage in activities like swimming, tennis, and dancing, while introverts tend to prefer activities like gardening and home improvement (Rhodes & Smith, 2006; Newsome et al., 2021). While consistent correlations have been demonstrated, these reviews did not establish causality between extraversion and physical activity behavior. Regardless, it seems the greater novelty and arousal sought by extroverts may lead to greater physical activity

levels, higher exercise intensities, and a stronger affinity for group exercise compared to introverts.

Affective Responses

Core affect is the rudimentary feeling state that underlies all emotions, including anxiety. Feelings of anxiety, including SPA, are constructed by dimensions of valence (pleasure-displeasure) and arousal or perceived activation (low-high) and are often studied by exercise scientists as changes in core affect under the umbrella term affective responses. For sedentary individuals, higher exercise intensities have been shown to invoke greater feelings of displeasure than moderate or low intensities, with feelings of pleasure maximized when the intensity is self-selected (Ekkekakis et al., 2011). Exercise can reduce anxiety and improve feeling states regardless of a self-selected or imposed intensity, although there appears to be no difference between intensities (Focht & Hausenblas, 2003, 2004; Focht, 2007; Knappen et al., 2008).

"Dark" Exercise Classes Are Currently Trending

Exercise classes in the dark, or under conditions with dim lighting, have gained popularity in recent years. Some group cycling classes, otherwise known as "spin classes," are hosted in low-lighting conditions. Some research has shown these classes to be more enjoyable when led by an instructor compared to when they are performed alone (Szabo et al., 2015). The dark environment reportedly helps shift focus away from bodily self-awareness (e.g., muscle discomfort) and to the activity itself (Graham, 2016; Lapidos, 2019). However, there is no empirical evidence for this phenomenon, nor is it

referenced in the American College of Sports Medicine's guidelines (ACSM) (Liguori et al., 2022).

The affective impacts of light on humans have been well studied. A review by Cajochen (2007) found that alertness has a direct logistic relationship with brightness, measured in lux, the standard international units for measuring brightness. The logistic relationship plateaus at approximately 1000 lux, meaning no additional increase in light will increase arousal. Light with a higher core-color temperature (CCT) has been shown to be more alerting than light with a lower CCT. CCT scales with wavelengths of light; red light has a low CCT and blue light has a high CCT. Higher CCT light has been shown to increase physiological parameters of arousal such as heart rate and core body temperature, particularly at night (Souman et al., 2018). This type of light is also used in light therapy, which has been shown to effectively treat seasonal affective disorder (Peiser, 2009). Evidence suggests that exercise is an effective treatment of seasonal affective disorder, although light therapy is a primary treatment for this condition (Howland et al., 2009).

The effects of environmental light levels during exercise have been used to assess various psychological and physiological outcomes. Some of these include alertness and performance. O'Brien and O'Connor (2000) found that different pairs of sunglasses worn in front of a 12,000 lux light box (akin to full daylight without direct sunlight; Preto & Gomes, 2018), which resulted in retinal light exposures of 1,411, 2,788, and 6,434 lux (akin to an overcast day, which ranges from 1,000-10,000 lux; Preto & Gomes, 2018), did not influence alertness during 20-min bouts of stationary cycling. Possible explanations for these null results are that light exposure durations were too short to have an effect, as

participants were only exposed to the light during the cycling bout, or that the lighting intensities were too similar as all light conditions were described as “bright.” To investigate this further, Ohkuwa et al. (2001) exposed participants to 90 minutes of bright (5000 lux) or dim (50 lux) light before a supramaximal exercise test in medium (500 lux) lighting, finding no significant differences in power output. Kantermann et al. (2012) and Knaier et al. (2015) also sought to improve the study design. Both studies exposed participants to 120 minutes of bright (4,420 lux) or medium (230 lux) light before 40-minute cycling bouts with the same brightness intensities. However, they found participants had significantly greater power outputs in the bright light condition compared to the medium light condition. Both studies also administered sessions based on each participant’s chronotype (“biological clock”). Inversely, Nelson et al. (2015) found that muscular endurance, measured by the number of knee extension repetitions to failure, was reduced after one hour of darkness exposure (<50 lux) compared to one hour of exposure to standard room lighting. All muscular endurance assessments were performed in standard room lighting. A notable limitation of this article is that specific brightness for the standard room lighting was not given. Another study found no differences in dim and bright lighting on feelings of energy, effort, and tiredness during bouts of stationary cycling (Shaulov & Lufi, 2009). This study is also limited by specific brightness values not being provided for the dim and bright lighting conditions. Leppämäki (2006) found that both exercise and bright light (2500 lux) equally helped treat depressive symptoms, with even greater efficacy found when combining these interventions. It is worth noting that exercise intensity was not measured in this study. This is a limitation considering the well-established relationship between exercise

intensity and affective responses (Ekkekakis et al., 2011). While the effects of light levels on exercise performance are inconsistent, performance may change, provided there are notable differences in light levels and adequate exposure times.

Exercise in the Dark

There is a limited amount of literature examining the effects of exercising in the dark. Previous research has examined the relationship between different brightness levels and exercise performance, although few have done so with dark conditions. Kriel et al. (2007) found no significant differences in mean heart rate, power output, ratings of perceived exertion (RPE), and completion times for cycling time trials in standard room lighting and absolute darkness. It is noteworthy that specific brightness intensities were not given for either condition. Pinheiro et al. (2015) found that cycling in light-deprived conditions (~2 lux) reduced the duration of time-to-exhaustion tests compared to standard room lighting (~224 lux) in untrained cyclists. Psychological and physiological variables (i.e., oxygen consumption (VO_2), heart rate, RPE) did not significantly differ at exhaustion. Pinheiro et al. (2016) conducted a similar study with the same lighting conditions but with a time trial protocol in trained cyclists. Pacing and performance were unaffected by lighting conditions. Notably, for both studies by Pinheiro and colleagues, a flashlight was briefly used every minute to illuminate measurement scales in the light-deprived condition. Thus, it is unlikely the mean brightness level was ~2 lux.

A gap in the literature exists in that no one has examined the effect of low ambient light levels on feelings of SPA and pleasure during group exercise classes. This is important because dark environments may reduce the visual perception of other

individuals as it is simply more difficult to see other patrons, thereby reducing self-comparison. Therefore, exercising in the dark may significantly reduce SPA. Reductions in SPA may potentially be associated with greater pleasure during exercise. Furthermore, given the literature on individual differences in exercise preferences (Rhodes & Smith, 2006), extroverts and introverts may respond differently to exercising in the dark, based on their perceived level of sensory stimulation and SPA. For example, extroverts tend to prefer exercising in a group compared to introverts, who prefer exercising alone (Newsome et al., 2021). However, extroverts with SPA may opt out of their preferred exercise out of fear of social comparison. Therefore, exercising in the dark may allow extraverts to exercise in their preferred modality without increasing levels of SPA. Another possibility is that various light intensities have the same effect on arousal, provided a threshold (i.e., 1000 lux) of objective brightness is reached. Whether these possible changes in arousal are pleasurable or not may be partially determined by extraversion-introversion.

The purpose of this study was to investigate the effect of ambient light intensity on the subjective exercise experience. Specifically, the effect of ambient light levels on social physique anxiety, affective responses, and future intention to exercise was measured following group cycling exercise in both standard room lighting and darkness.

Primary Aim

To evaluate the subjective exercise experience of group cycling exercise in the dark (~0 lux) compared to standard room lighting (~180 lux; Boivin et al, 1996).

H1: SPA will be lower in the dark condition compared to standard room lighting.

H2: Introverts will feel more pleasure exercising in the dark compared to extroverts.

CHAPTER 3

METHODOLOGY

Participants

Sample size calculation was based on a within-subjects comparison of declines in ratings of pleasure–displeasure between two 15 min cycling exercise conditions (Ekkekakis et al., 2008) which resulted in a large effect (d=0.81). Therefore, considering a large effect for a comparison between two dependent means (d=0.80), α=0.05 and $1-\beta$=0.80, a sample size of 15 was the minimum required to yield sufficient statistical power.

The inclusion criterion was healthy adults aged 18-65 years. Exclusion criteria included depression, pregnancy, a self-reported fear of the dark, a vestibular disorder (i.e., benign paroxysmal positional Vertigo), and the ACSM (American College of Sports Medicine) risk stratification criteria to reject high-risk individuals, an established risk stratification procedure used in exercise studies (Liguori et al., 2021). Participants were recruited from a university-wide recruitment email, posted flyers, and word-of-mouth. There was no compensation for participation. This study was approved by the University of Rhode Island Institutional Review Board (2149814-3).

Measures

Primary Measures

Social Physique Anxiety. Social physique anxiety was measured as both a trait and a state. As a trait, it was measured with the Social Physique Anxiety Scale (Hart et al., 1989). This is an evidence-based 12-item self-report scale assessing SPA with scores ranging from 12-60. It has been validated for use in both males and females. As a state, it is measured with the State Social Physique Anxiety Scale (Martin Ginis et al., 2011). While it has only been validated for use in females, it is a modified version of the SPA Scale. It is an evidence-based 9-item self-report scale assessing social physique anxiety with scores ranging from 9-45. The higher the scores, the greater one's feeling of SPA is.

Affective Responses. Affective responses were measured as valence (pleasure-displeasure) and arousal (perceived activation). Valence was measured with the Empirical Valence Scale (EVS; Lishner et al., 2008). The Empirical Valence Scale measures emotional valence with verbal descriptors ranging from "most unpleasant imaginable" to "most pleasant imaginable." This scale is an empirically derived measure of assessing pleasure-displeasure. Arousal was measured with the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985). The FAS measures how "worked up" someone feels. Values range from +1 to +6, with higher scores interpreted as greater arousal.

Extraversion-Introversion. Extraversion-introversion is one of the five personality traits featured in the five-factor model of personality ("Big Five"). Extraversion has the strongest absolute correlation with physical activity maintenance (Rhodes & Smith, 2006; Wilson & Dishman, 2015; Sutin et al., 2016). It is measured with the Big Five Inventory,

a 44-item questionnaire developed to measure an individual's traits of extraversion, openness to experience, neuroticism, agreeableness, and conscientiousness (John et al., 1991).

Secondary Measures

Perceived Evaluative Threat. Participants were asked to rate their level of perceived evaluative threat (PET) for the environment of each condition. Consistent with procedures used in previous research (Hart et al., 1989), participants were specifically asked to rate how threatening the exercise environment was in terms of having their physique evaluated. Participants provided ratings using a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely).

AFFEXX. The Affective Exercise Experiences Questionnaire is a 36-item questionnaire that measures an individual's feelings toward exercise. Items are measured with a 7-point Likert scale (Ekkekakis et al., 2021). This measure was used to describe the sample in terms of feelings about exercise.

IPAQ-SF. The International Physical Activity Questionnaire Short Form is a 7-item self-report questionnaire assessing an individual's physical activity behavior in the previous seven days (Craig et al., 2003). Participants were asked to report the frequency and duration of their physical activities, which were categorized based on intensity. Vigorous activities were defined as those requiring hard physical effort and causing the participant to breathe much harder than normal (e.g., running, aerobics), whereas moderate activities required moderate physical effort and caused the participant to breathe somewhat harder than normal (e.g., brisk walking, gardening).

For each activity type, participants recorded the number of days per week they engaged in the activity and the average time spent per day. The Metabolic Equivalent of Task (MET) values used for calculation were 8 METs for vigorous activities, 4 METs for moderate activities, and 3.3 METs for walking. Weekly MET-minutes were computed by multiplying the number of days by the minutes per day and then by the respective MET value. Specifically, vigorous activity was calculated using the formula Days × Minutes/day × 8, moderate activity using Days × Minutes/day × 4, and walking using Days × Minutes/day × 3.3. The total MVPA MET-minutes per week were determined by summing the MET-minutes from both vigorous and moderate activities. While walking MET-minutes were included in overall physical activity calculations, they were not included in MVPA calculations.

Future Intention. Participants rated their behavioral intention to continue exercising in a lighting condition by rating their intention on a seven item questionnaire with all items featuring a seven-point scale. It was qualitatively assessed by asking participants the following question: "If you had to repeat either session (pitch black vs normal room lighting) which one would you choose and why?" (Ajzen, 1991).

Novelty. Given the novel nature of this study, participants completed a basic questionnaire about their experience with the study. The goal was to acquire qualitative information about exercising between lighting conditions. Questions included the following:

1. "Have you ever participated in a spin class before?"
2. "If you had to repeat either session (pitch black vs normal room lighting) which one would you choose and why?"

3. “Can you guess the purpose of this experiment?”

Procedures

Participants completed two group cycling exercise sessions (light and dark conditions) on stationary bikes (Monark, 828E) for 20 minutes (Martin-Ginis et al., 2003) at a self-selected intensity. Each condition was performed seven days apart. This exercise consisted of a five-minute warmup and a 15-minute self-selected phase. Participants were allowed to adjust the pedal resistance to whatever they found most comfortable, and were instructed to choose a seat height that allowed for a slight knee angle when seated with their foot in the pedal at the furthest pedal position. For safety, participants were instructed to remain seated throughout the cycling session, keep both hands on the handlebars at all times, and not stand up or sway. In the dark condition, a researcher wore night vision goggles (Nightfox, Swift) to watch the participants for safety. Small pieces of glow-in-the-dark tape were placed on the ends of handlebars of the stationary bikes to provide the participants with a sense of position in space.

The difference between conditions was the level of room lighting: either ~180 lux for the standard room lighting (LIGHT) session, or ~0 lux for the darkness session (DARK). Lux was measured with a lux meter (LX1330B, Dr. Meter). Ambient light intensity was manipulated by turning the room lights on and off. There were no mirrors or windows in the room that participants cycled in, and they all faced a blank wall when cycling. A playlist of songs averaging 121 beats per minute played in the background while participants exercised; this tempo is standard for exercise (Jones et. al., 2024). No songs repeated and the same playlist was used in both conditions with the songs in the

same order. The purpose of the playlist was to increase external validity by making the cycling sessions more closely resemble a “spin” class.

Informed consent was obtained at the beginning of the first condition. The Trait SPA, Big Five, AFFEXX, and IPAQ-SF were administered at this time. State SPA, EVS, and FAS were administered at this time, immediately before the cycling exercise and five minutes after the exercise. The PET measures and future intention questionnaire were also completed post-exercise. The first session lasted approximately one hour and the second lasted approximately 30 minutes. The differences in durations resulted from the delivery of initial instructions, the time needed to adjust bike seat heights, and the time needed for participants to complete the Trait SPA, Big Five, AFFEXX, and IPAQ-SF questionnaires; each of these took approximately 3-5 minutes to complete. The state SPA, EVS, FAS, and PET each took approximately 5-10 seconds to complete. The future intention to exercise questionnaire took approximately 1 minute to complete. Lastly, the novelty questionnaire took approximately 2 minutes to complete.

Sessions were originally intended to be counterbalanced; participants returned one week later at the same time of day to exercise in the other light condition. The procedure for the dark condition was the same as the light condition, except light intensity was ~0 lux and the novelty questionnaire was administered post-exercise in addition to the other questionnaires. A researcher wore the night vision goggles during the cycling exercise to ensure participant safety.

Statistical Analyses

All statistical analyses were conducted using the IBM Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA), version 29.0.1.0. Descriptive statistics were used to analyze the data. To test hypothesis 1, the following analyses were conducted: a series of 2 (condition: dark, light) by 2 (time: pre, post) repeated-measures ANOVAs were used to compare pre-post scores between the two conditions (light vs dark) for the State Social Physique Anxiety Scale, Empirical Valence Scale, and Felt Arousal Scale. A paired samples t-test was used to compare the Future Intention scores between the two lighting conditions. Correlations examined the change (post-pre) in SPA scores and change in EVS scores for each condition. To test hypothesis 2, correlations between extraversion and EVS post scores were examined for both lighting conditions. Results are reported as means, and standard deviations, and percent change. Statistical significance (α) was set at 0.05 and statistical power at $1-\beta = 0.80$.

CHAPTER 4

FINDINGS

RESULTS

Five participants ($n_{female} = 1$, $n_{male} = 4$) completed the study. The participants' average age was 25.0 ± 5.0 yrs. The average BMI was 24.78 ± 2.83 kg/m^2. The average self-reported physical activity level was 1536 ± 1157.51 MVPA/MET/min/week, indicating this was an active sample according to the ACSM guidelines. Participant demographics are further detailed in **Table 1.**

State SPA

The main effect of brightness condition (light vs dark); $F(1, 4) = .021$, $p = .891$, partial $\eta^2 = .005$, time (pre- vs post); $F(1, 4) = 5.565$, $p = .078$, partial $\eta^2 = .582$, and the interaction; $F(1, 4) = .069$, $p = .806$, partial $\eta^2 = .017$, were not statistically significant.

Overall, state SPA pre in the light condition (M = 18.6, SD = 5.5) was not significantly different from the dark condition (M = 18.0, SD = 6.67). Overall, state SPA post in the light condition (M = 15.8, SD = 5.76) was not significantly different from the dark condition (M = 16.0, SD = 5.01). Results are illustrated in **Figure 1.**

EVS

The main effect of brightness condition (light vs dark); $F(1, 4) = 5.252$, $p = .084$, partial $\eta^2 = .568$, time (pre- vs post); $F(1, 4) = 6.989$, $p = .057$, partial $\eta^2 = .636$, and the interaction; $F(1, 4) = .53$, $p = .507$, partial $\eta^2 = .117$, were not statistically significant.

Overall, EVS pre in the light condition (M = 15.8, SD = 21.81) was not significantly different from the dark condition (M = 28.6, SD = 10.14). Overall, EVS post in the light condition (M = 30.2, SD = 19.41) was not significantly different from the dark condition (M = 48.2, SD = .447). Results are illustrated in **Figure 2.**

FAS

The main effect of brightness condition (light vs dark); $F(1, 4) = 1.882$, $p = .242$, partial $\eta^2 = .320$, time (pre- vs post); $F(1, 4) = 7.579$, $p = .051$, partial $\eta^2 = .655$, and the interaction; $F(1, 4) = 3.273$, $p = .145$, partial $\eta^2 = .450$, were not statistically significant.

Overall, FAS pre in the light condition (M = 2.6, SD = .89) was not significantly different from the dark condition (M = 2.6, SD = .547). Overall, FAS post the light condition (M = 3.2, SD = 1.79) was not significantly different from the dark condition (M = 4.4, SD = .894). Results are illustrated in **Figure 3.**

PET

PET analyses could not be conducted due to a lack of variance (dark condition: M = 0, SD = 0).

Future Intention

Overall, future intention to exercise in the dark condition (M = 34, SD = 2.2) was not significantly different from the light condition (M = 33, SD = 4.0); $t(4) = -1.00$, $p = .374$, Cohen's $d = 0.25$. Results are illustrated in **Figure 4.**

Correlations between State SPA and EVS

There were no significant correlations between changes in State SPA and EVS in the light condition (r = .183, p = .768) or dark condition (r = -.116, p = .853).

Correlations between Extraversion and EVS

There were no significant correlations between extraversion and EVS post scores in the light condition (r = -.696, p = .192) or dark condition (r = .774, p = .124).

Correlations between Trait SPA and BMI

There was no significant correlation between trait SPA and BMI (r = .-196, p = .752).

Novelty

Two out of five participants reported they had participated in a spin class before. All five participants responded that they would rather repeat the dark (pitch black) lighting condition over the light (normal) lighting condition. Reasons included that it was novel, relaxing, and/or removed the element of comparison.

Participant 1: *"Pitch black, just because it's different."*

Participant 2: *"I was relaxed, allowing me to focus on only exercising."*

Participant 3: *"I would repeat the pitch black environment because it was a new experience for me and it was relaxing."*

Participant 4: *"Pitch black, it felt novel and fun and I felt like I could go my own pace and not match others."*

Participant 5: *"I think pitch black. It made me feel like I was exercising alone, which is what I like doing best. It allows me to exercise intensely with no worries about appearing like a tryhard."*

CHAPTER 5

DISCUSSION

The present study manipulated ambient light intensity to investigate its effect on the subjective exercise experience. The primary hypothesis was that state social physique anxiety (SPA) would be lower when group cycling exercising in the dark compared to standard room lighting. The secondary hypothesis was that introverts would feel more pleasure exercising in the dark compared to extroverts. The primary hypothesis was not supported because of the lack of a significant difference in state SPA scores between lighting conditions. Contrary to the secondary hypothesis, extraversion had a negative correlation with EVS scores in the light condition and a positive correlation in the dark condition. However, these correlations were not significant.

Qualitative results from the study indicated that arousal increases can likely be attributed to the participants focusing on the exercise itself, as some commented on how the dark condition allowed them to focus on doing so without the influence of others. This provides credibility to anecdotes about exercise classes in the dark that have been previously reported (Graham, 2016; Lapidos, 2019). This provides qualitative evidence consistent with previously mentioned anecdotes about the benefits of exercising in the dark.

While EVS scores increased from before to after the cycling exercise in both lighting conditions, this effect was not significant. This differs from the findings of Ekkekakis et al. (2008) who found significant improvements in valence post-exercise compared to pre-exercise. Our findings can likely be attributed to the low sample size,

which likely increased the risk of a type II error, potentially nullifying the discovery of significant changes in EVS scores.

Perceived evaluative threat was not significantly different between lighting conditions. This deviates from the findings of Focht and Hausenblas (2003), who found that in women high in social physique anxiety, exercising in front of a mirror and in the presence of other exercisers increased state anxiety and PET scores compared to exercising individually and without a mirror. The presence of others and mirrors likely increased their bodily self-awareness to their disdain. In this study, there were no mirrors or windows in the room, which may have reduced participants' bodily self-awareness independent of light levels.

No significant decreases in state SPA occurred between the lighting conditions, a finding that deviates from previous literature. Gammage et al. (2004) found that women who exercised in a room with all mirrors and windows covered reported lower SPA scores than women who exercised in a room with all the windows and mirrors exposed. In our study, there were no significant differences in state SPA between light conditions. One explanation as to why this occurred is because of the relatively low trait SPA of this cohort. Trait SPA in this study was much lower than some other studies (Schwerin et al., 1996; Chu et al., 2010; Martin Ginis et al., 2011) but is consistent with the findings of Portman et al. (2018). It is also consistent with the scores reported by men in response to a hypothetical mixed-sex exercise class (Kruisselbrink et al., 2004). Thus, the low trait SPA in this study is likely due to the primarily male sample, the overall low sample size and statistical power, along with normal BMI ranges within the sample. As there was no significant correlation between trait SPA and BMI, it appears less likely that a change in

state SPA would be seen in this cohort. Additionally, most of the participants were male, which may have resulted in the means for trait and state SPA of the cohort being relatively low as males do not experience SPA to the same degree as women. Limited research indicates that men are also unaffected by the presence of mirrors in group exercise classes (Despain, 2017).

Future intention to exercise was not significantly different between light conditions. This was likely because IPAQ-SF scores were high, indicating the participants were already engaging in regular physical activity, and thus were planning to continue to do so regardless of feelings of pleasure or novelty from this study.

This pilot study novelly evaluated the phenomenon of exercising in the dark on SPA. The current findings add to the body of exercise psychology literature by demonstrating that exercising alone can be simulated in a group setting by reducing environmental lighting, providing preliminary support for the growing trend of exercise classes in the dark. These classes are a novel approach to making exercise more enjoyable, which has been called for in prior literature (Ekkekakis, 2017). Expanding exercise classes in the dark may help those intimidated by public gyms (i.e., sedentary women) to participate in exercise by reducing feelings of SPA, increasing pleasure and/or reducing feelings of displeasure, thus increasing intrinsic motivation, which has a positive relationship with intention continue exercising, enjoyment, and exercise persistence (Rodrigues et al., 2019). Even for individuals low in SPA, such classes can be a unique and interesting way to participate in exercise.

Limitations

This study has several limitations. First, the study was not adequately powered with five participants due to low recruitment numbers. Thus, its generalizability to the public is limited by its small sample size. Consequently, we are unable to support either of our hypotheses. Additionally, the conditions were not counterbalanced for future cohort groups due to the low recruitment that resulted in a single group cohort of five participants. The resulting single cohort, and lack of counter-balance, cannot control for potential practice or ordering effects (e.g., temporal effect of asking qualitative data only after the dark session). Taken together, the lack of a correlation between extraversion and EVS scores, despite the medium to large magnitude of association, is likely a consequence of the small sample size. As such, the potential phenomenon posited by our secondary hypothesis could not be detected. An additional limitation was that the sample featured exclusively active participants. Thus, the results cannot be extrapolated to the generally sedentary population. For safety reasons, participants were only exposed to the darkness while sitting on the stationary bikes, meaning they participants were exposed to natural lighting during other parts of the study (i.e., completing questionnaires, adjusting seat heights, etc.). This allowed them to see and interact with other participants, which could have impacted state SPA. Additionally, the lab environment may have been less anxiety-inducing compared to a real-world gym, which may have lowered state SPA scores. Inversely, generalized anxiety disorder was not screened for, thus it may have acted as a confounding variable in the context of trait and state SPA scores.

Future Directions

Future research should focus on primarily recruiting sedentary female participants, as this population is the most susceptible to experiencing increases in state SPA induced by fitness centers. Researchers should aim to host group exercise sessions in public fitness facilities to increase external validity, as individuals with state SPA are often deterred from exercising in such environments. The small sample size of this study resulted from difficulties with recruitment, which can be addressed with the use of incentives. Ideally, future studies should also employ a mirrored condition as a second experimental condition to evaluate any potential increases in state SPA, and compare the results to that of an unmirrored light condition and dark condition.

Conclusion

This study assessed how exercising in the dark may influence the subjective exercise experience. It is a novel intervention that removes the element of comparison and allows individuals to focus on the exercise itself. As exercise participation remains low and global obesity rates are on the rise, interventions that make exercise more enjoyable will become increasingly important.

APPENDICES

Table 1. Participant demographics. *Note.* BMI = Body Mass Index. Trait SPA = Trait social physique anxiety. IPAQ-SF = International Physical Activity Questionnaire Short Form. AFFEXX = Affective Responses Towards Exercise Questionnaire.

Variable	Mean	SD
Age (yrs)	25	5
BMI (kg/m^2)	24.78	2.826
Trait SPA	18.6	11.247
IPAQ-SF (MVPA/MET/ min/week)	1536	1157.51
Extraversion	26.8	3.033
AFFEXX		
Interest	6.75	0.5
Honor	6.6	0.724
Empower	6.8	0.447
Showoff	5.07	1.553
Likegroup	4.87	1.773
Competence	5.95	1.292
Pleasure	6.35	0.894
Energy	5.85	1.636
Calmness	6.1	0.978
Attraction	6.5	0.574

Table 2. Means and standard deviations of outcome variables between each lighting condition. *Note.* SPA = state social physique anxiety. EVS = Empirical Valence Scale. FAS = Felt Arousal Scale. PET = perceived evaluative threat.

Variable	Light		Dark	
	Mean	SD	Mean	SD
State_SPA_Pre	18.6	5.5	18.0	6.67
State_SPA_Post	15.8	5.76	16.0	5.01
EVS_pre	15.8	21.18	28.6	10.14
EVS_post	30.2	19.41	48.2	0.447
FAS_pre	2.6	0.89	2.6	0.547
FAS_post	3.2	1.79	4.4	0.894
PET	0.4	0.547	0.0	0.0
Future Intention	33	4.0	34	2.2

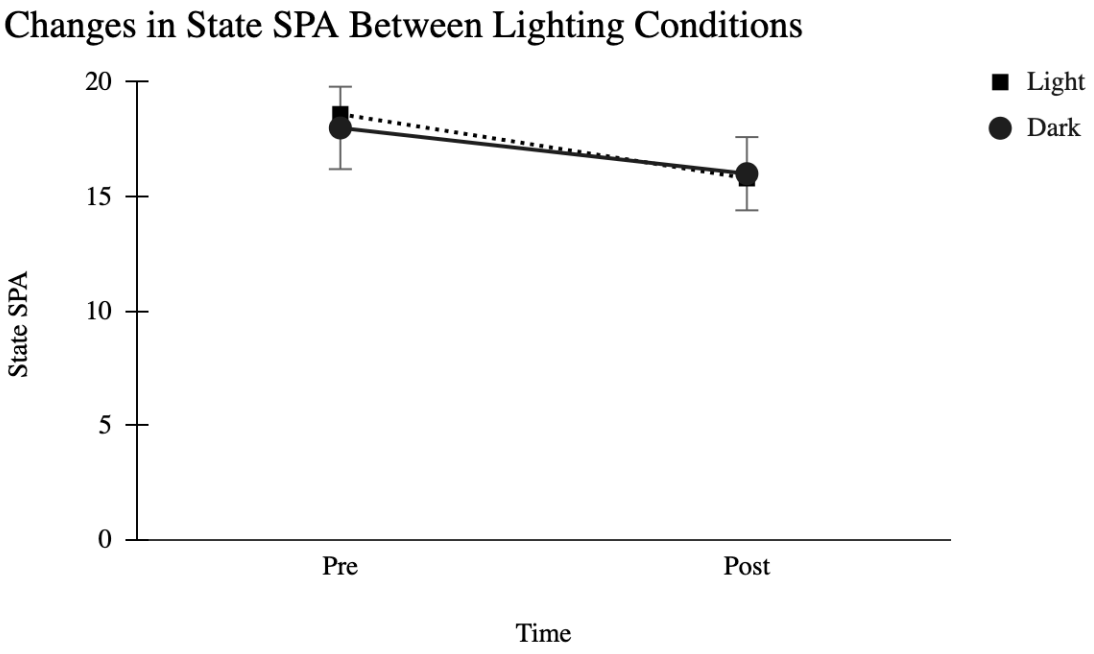

Figure 1. State SPA values before and after the cycling exercise. *Note.* State SPA = state social physique anxiety. Light = ~180 lux. Dark = ~0 lux. Error bars represent standard error of the mean (SE).

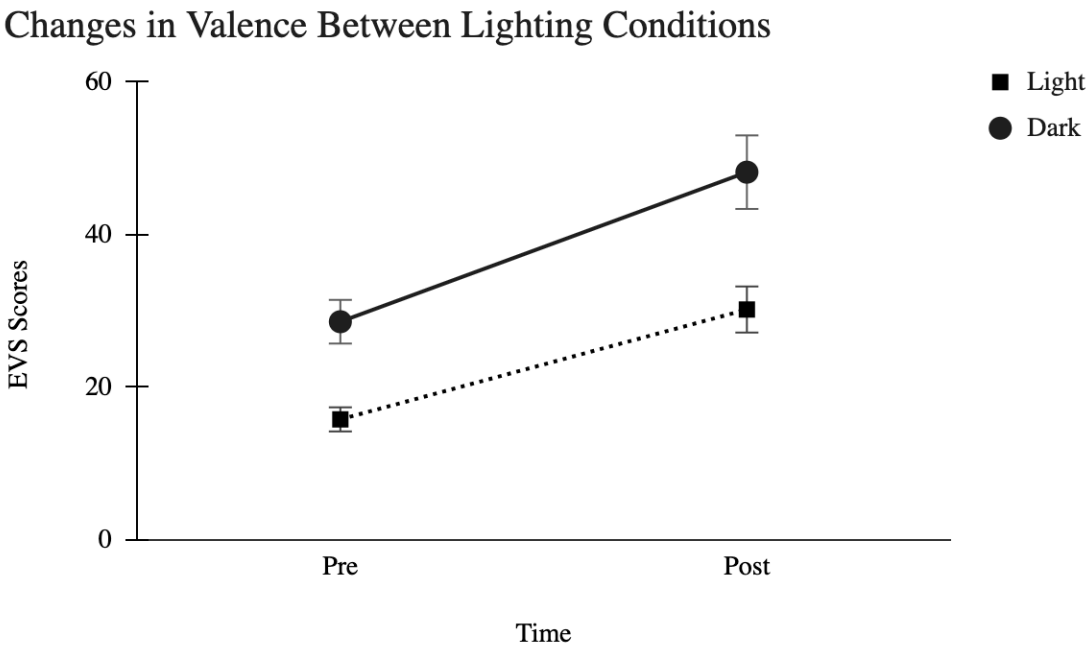

Figure 2. Valence values before and after the cycling exercise. *Note.* EVS = Empirical Valence Scale. State SPA = state social physique anxiety. Light = ~180 lux. Dark = ~0 lux. Error bars represent standard error of the mean (SE).

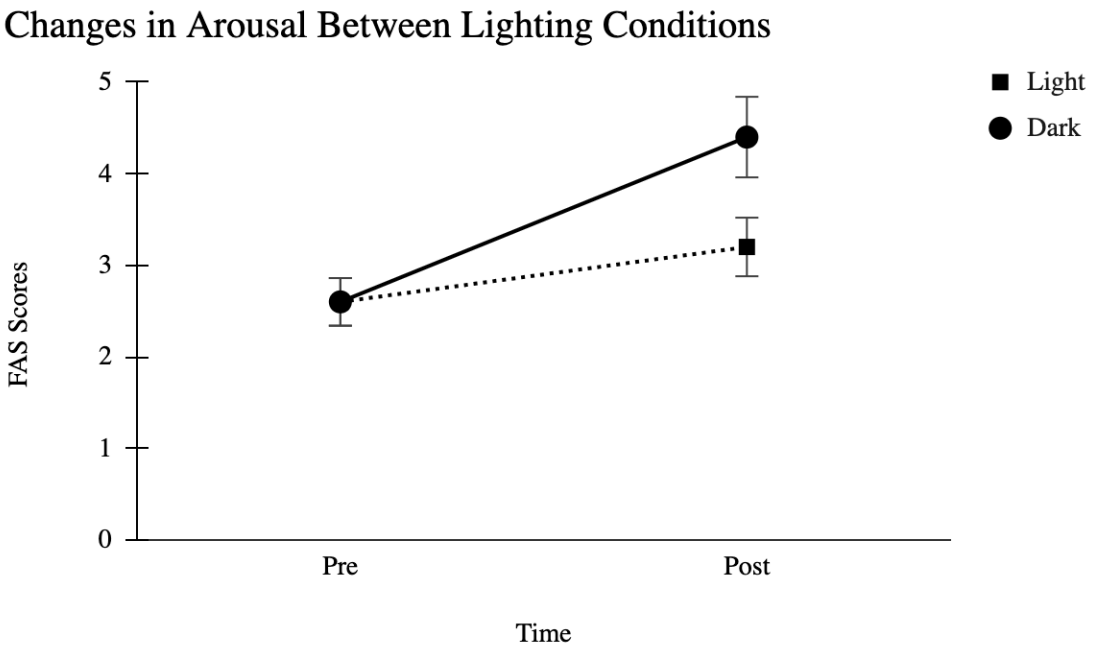

Figure 3. Arousal values before and after the cycling exercise. *Note.* FAS = Felt Arousal Scale. Light = ~180 lux. Dark = ~0 lux. Error bars represent standard error of the mean (SE).

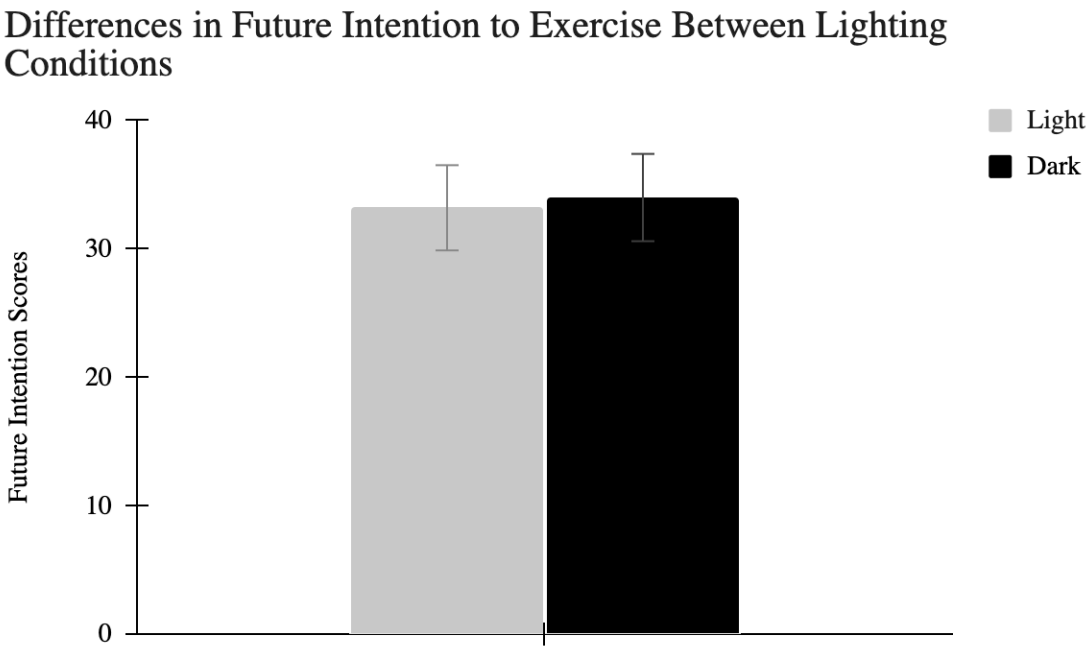

Figure 4. Differences in future intention to continue exercising before and after each session. *Note.* Light = ~180 lux. Dark = ~0 lux. Error bars represent standard error of the mean (SE).

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