2019-07-01

Sleep, Stress, and Sweat: Implications for Client Physiology Prior to Couple Therapy

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A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

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ABSTRACT

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Physiological state greatly influences one's ability to emotionally regulate and connect to a partner in couple therapy. As individuals encounter real or perceived threats in relationships, they are likely to experience sympathetic nervous system (SNS) responses of fight, flight, or freeze, thereby inhibiting the ability to connect with a partner or therapist made possible by the parasympathetic nervous system (PNS). This study, guided by the Polyvagal theory, examines the influence of client sleep, daily stress, and exercise on physiological baseline prior to a couple therapy session. Participants included 23 married couples who attended couple therapy at the Brigham Young University (BYU) Comprehensive Clinic. We examined the influence of client number of awakenings, sleep fragmentation index (SFI), daily stress time, and daily exercise time on measures of physiological baseline which included Galvanic skin response (GSR), respiratory sinus arrhythmia (RSA) and pre-ejection period (PEP) of the left ventricle of the heart. Three multi-level models were conducted to analyze the influence of sleep, stress, and exercise on GSR, RSA, and PEP respectively. Results indicated that daily stress significantly predicts PEP baseline as a measure of SNS fight-or-flight activation. A discussion of potential limitations, recommendations for therapists, and suggestions for future research are included.

Keywords: couple therapy, sleep, stress, exercise, Polyvagal Theory, autonomic nervous system

ACKNOWLEDGEMENTS

I would like to recognize the many individuals who have supported me through this project and made this research possible. I am, first and foremost, profoundly grateful for my committee chair and friend, Lee Johnson who has encouraged and helped me in this research. Additionally, I am very grateful for Angela Bradford, Brian Willoughby, and Jeff Hill who have served on my committee. I would also like to express my appreciation to my husband, Larsen, who has been patient, considerate, and loving throughout this entire process. I am thankful for parents who have always supported my educational pursuits and for their thoughts and prayers on my behalf. Finally, I am grateful for many researchers who have gone before me and have made this project possible through their contributions. I feel very fortunate to benefit from the advancements of so many who have shaped and are currently shaping the field of Marriage and Family Therapy.

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Couple therapy has been proven to be effective in treating relationship distress (Lebow, Chambers, Christensen, & Johnson, 2012; Sprenkle, 2012). However, it is estimated that only two-thirds of individuals receiving couple therapy will experience beneficial outcomes when compared with control groups (de Maat, de Jonghe, Schoevers, & Dekker, 2009; Shadish, Ragsdale, Glaser, & Montgomery, 1995). Other research suggests that the average treated person is better off than approximately 80% of the untreated sample (Lambert & Ogles, 2004). While distressed couples who attend therapy are usually better off than those who do not, couple therapy outcomes still have room for improvement. Recently, the research focus in couple therapy has been shifting from the efficacy of model-specific interventions to relational variables that influence therapy outcomes and change processes (Messer & Wampold, 2002; Orlinsky, Ronnestad, & Willutzki, 2004).

However, little is known about which specific factors lead to client progression and change (Lambert, 2013). To better understand change, recent research has focused on identifying factors that lead to progression and change for couples in therapy (Johnson, Selland et al., 2017; Johnson, Miller, Bradford, & Anderson, 2017). One area that shows promise in facilitating client change is the application of physiology to couple therapy (Taylor, Seedall, Robinson, & Bradford, 2017; Karvonen, Kykyri, Kaartinen, Penttonen, & Seikkula, 2016). As more is being discovered about relationship processes and physical responses, the intersection between physiology and therapy is an area worth exploring. In recent years, the connection between emotion and physical responses has been a more highly considered factor in therapy (Johnson, Selland et al., 2017). While the field of marriage and family therapy has begun to understand these dynamics, further exploration is needed to understand the role of client physiology as it relates to relationship processes.

While the exploration of physiology in couple therapy is fairly new, there is some research from individual psychology which suggests that physiology can influence therapeutic processes and relationships between individuals in therapy (Kleinbub, 2017; Coutinho, Silva, & Decety, 2014; Dimascio, Boyd, & Greenblatt, 1957; Fagundo et al., 2014). Additional research has explored how physiology influences responses in close relationships (Porges, 2007; Roisman, 2007). Polyvagal Theory (Porges, 2007) suggests that the human body needs both social connection and safety. These two needs are regulated by the autonomic nervous system (ANS). The ANS is divided into two sub-systems—the parasympathetic nervous system (PNS), which regulates resting, digesting, socially connecting, and freezing (feigning death) responses, and the sympathetic nervous system (SNS) which regulates the body's fight/flight and behavior inhibition responses (Porges, 2007). In couple therapy, it is critically important that clients can emotionally connect to each other and the therapist in order to make progress (Anderson & Johnson, 2010; Bourgeois, Sabourin, & Wright, 1990; Knobloch-Fedders, Pinsof, & Mann, 2007). Therefore, the ideal physiological state for therapy would be one in which clients' and therapist's PNS is controlling physical responses and regulating emotions.

However, physiological reactions are outside of conscious control and occur in a matter of milliseconds (Porges, 2011), and while it would be ideal for all clients to come to therapy perfectly regulated and ready to emotionally connect, the reality is far from ideal. For example, an argument before session will likely alter both clients' physiological states resulting in increased heart rate, blood pressure, and respiration rate. These responses are related to the activation of the SNS which moves the body into fight/flight or behavior inhibition. Therefore, it is possible that a client's physiological state could be determined by events which precede therapy. A client's physiological state prior to therapy will likely positively or negatively influence his or her experience during the session and interactions within it.

If a client comes to a therapy session already in a stage of fight or flight, it may prevent emotional connection between spouses and the therapist (Porges, 2011). Emotional connection is an integral component of successful couple therapy. An inability to emotionally connect can slow therapy progress and make change more difficult. When a client has a more regulated physiological arousal at the beginning of therapy, they may also have greater control over emotional reactivity, and may likely have an easier time emotionally connecting with a partner and the therapist. This connection allows therapy to be more conducive to positive change (Anderson & Johnson, 2010; Bourgeois et al., 1990; Knobloch-Fedders et al., 2007). Therefore, it is important to study factors which contribute to clients being in a receptive physiological state. There are many factors which influence a client's physiological state (Koban & Wager, 2016; Tamashiro, 2015), but this study will focus on sleep (Mauss, Troy, LeBourgeois, 2013), stress (Childre & Martin, 1999), and physical exercise (Johnson, Mennenga, Ellsworth, & Nancoo, 2012). The purpose of this study is to examine the influence of client sleep, stress, and exercise on physiological arousal at the beginning of a therapy session.

Literature Review

To better understand the need for the current study, this literature review will briefly explain Polyvagal Theory, the guiding theory of this research, as well as review other relevant related literature. Next, we will review literature linking physiology with sleep, stress, and exercise. Because literature on physiology and couple therapy is scarce, the bulk of the literature presented will primarily be on physiological connections to individuals or from individual therapy with suggested applications for couple therapy.

Polyvagal Theory

The Polyvagal Theory (Porges, 2007) helps us understand the functioning of the ANS in affective experience, emotional expression, facial gestures, vocal communication and relationships. As all of these elements are present in relationships and couple therapy, this theory is helpful in providing information on what may occur physiologically in a relationship and therapeutic settings.

According to Porges, the human brain is wired for both social connection and survival (Porges, 2011). These two functions are regulated by the ANS through the activation of the SNS and the PNS (Porges, 2011). One of the central components of the PNS is the vagus nerve which is divided into two branches. The dorsal vagal complex (DVC) is evolutionarily primitive and promotes freezing (feigning death) responses in a life-or-death situation. On the other hand, the ventral vagal complex (VVC), is more evolved and is associated with motion, emotion, and communication. However, the PNS functions of social and emotional engagement de-activate for the activation of the SNS survival responses when a real or imagined threat is perceived (Porges, 2007; Porges, 2011). The primary method of identifying PNS activity is through vagal tone. Vagal tone is measured through respiratory sinus arrhythmia (RSA) and is an important indicator of the body's baseline PNS functioning (Porges, 2009). Therefore, baseline RSA indicates an individual's current ability to emotionally regulate and connect in relationships (Porges, 2009; Whitson & El-Sheikh, 2003).

As clients perceive threats in therapy, the likelihood of being able to emotionally connect to a partner or therapist is diminished. Many individuals feel threatened in vulnerable states associated with romantic relationships, which can activate the SNS system's survival mechanisms exhibited as defensiveness, anger or other protective behaviors. When this occurs, an individual's ability to provide empathy for and soothe a partner is reduced. In essence, the absence of relational safety hinders the emotional connection required to make progress in couple therapy.

Physiology and Couple Therapy

While this study does not focus on couple-level variables, it is important to consider how both partner's physiology may influence therapy. Emotional connection is an integral component in fostering change and progression in couple therapy (Anderson & Johnson, 2010; Bourgeois et al., 1990; Knobloch-Fedders et al., 2007). This emotional connection has been researched within the working or therapeutic alliance. In couple therapy, the therapeutic alliance is between the therapist and both clients and within the couple relationship (Pinsof, 1994). While all alliances are key factors in creating change, research indicates that the within-systems alliance is a stronger predictor of improvement early in treatment (Anderson & Johnson, 2010; Knobloch-Fedders et al., 2007; Pinsof, Zinbarg, & Knobloch-Fedders, 2008). This is likely due to the unique emotional connection between partners. Therefore, if clients have a stronger within-systems alliance and are able to emotionally connect, they will likely make greater progress in couple therapy.

The ability to emotionally connect to a partner is dependent upon an individual's physiological state. As both partners move into a state of fight or flight, the ability to emotionally connect becomes diminished. Furthermore, even if one client becomes physiologically aroused, emotional connection can be strained. One client moving into a state of fight or flight is highly possible as physiological responses may vary for men and women responses (Taylor et al., 2000; Turton & Campbell, 2005). Because men tend to engage in more fight or flight behaviors (Taylor et al., 2000) it is possible that women may have a lower physiological baseline. Even if one partner is in a state of fight or flight, emotional connection becomes difficult. As previously mentioned, emotional connection is imperative for a couple to make progress in a therapeutic setting. If clients' physiological states influence emotional connection which leads to progression in therapy, then it is important for clinicians to understand how physiological responses influence relationships and how physiological responses may differ by sex.

Therapists need to understand how physiology may influence clients as physiological state may foster greater progress in therapy. Specifically, therapists need to be aware of lifestyle habits which widen the window of tolerance for clients. This study is meant to assist in that awareness by focusing on specific factors which influence individual physiology, thereby influencing the couple relationship and the progression of therapy. Those factors include healthy sleep (Mauss et al., 2013), reduction of stress (Childre & Martin, 1999) and regular exercise (Deslandes et al., 2009; Stathopoulou, Powers, Berry, Smits, & Otto, 2006). We will now discuss each of these factors in greater depth and explain how they influence physiological reactivity.

Sleep and Physiology

Sleep has a very profound impact on mental health and physiology. According to Loehr and Schwartz (2003) sleep is one of the most important sources of recovery for humans. Additional findings indicate that mental performance (e.g., reaction time, concentration, memory and logical/analytical reasoning) steadily declines as individuals accumulate sleep debt (Loehr & Schwartz, 2003). Insufficient sleep is also associated with greater mortality risk (Patel et al., 2004; Loehr & Schwartz, 2003), health complaints, and mood disturbances (Pilcher, Ginter, & Sadowsky, 1997).

Quality of sleep also has many implications for physiology. Sleep quality has been found to influence stress responses. A recent study identified sleep quality as a moderator between stress and affect, indicating that an individual's mood will be less affected by stress after high quality sleep (Flueckiger, Lieb, Meyer, Witthauer, & Mata, 2016). Additionally, more regulated physiology and quality sleep reduce internalizing symptoms such as anxiety, emotionality, and depression in children (Sunghye, Philbrook, Davis, & Buss, 2017). Although this study focuses on children, it nonetheless illustrates the connection between sleep quality and physiology.

The impact of sleep on individual physiology also manifests in couple relationships. Satisfaction in close relationships requires making decisions that favor the relationship, even when individuals are faced with threatening partner or relationship qualities which may activate the SNS (Maranges & McNulty, 2017; Murray & Holmes, 1994). Making these kinds of judgements requires sufficient cognitive resources that are necessary to override any opposing judgements. Adequate sleep is one of the primary ways to ensure enough cognitive resources for these evaluations (Maranges & McNulty, 2017). A recent study of newlywed couples indicates that couples were more satisfied with their relationship on days they had slept longer (Maranges & McNulty, 2017). This is likely because physical conditions, such as exhaustion, diminish emotional regulation in individuals (Mauss et al., 2013). Diminished emotional regulation may cause individuals to be more "vulnerable to irritability and emotional outbursts" in couple relationships (Siegel, 2012, p. 283). On days following a sufficient night's sleep, couples may have greater emotional regulation allowing them to navigate interactions or behaviors in the relationship which would normally be perceived as threatening and could activate SNS responses. Therefore, when an individual has sufficient sleep, they are more emotionally regulated and therefore better able to interpret the behaviors of their partner more favorably, which buffers against perceptions of threat and activation of the SNS.

The research summarized in this section indicates the importance of a client's daily (or, in this case, nightly) experiences prior to a therapy session. Sleep contributes to higher cognitive functioning, higher tolerance against the effects of stress, and a greater capacity to avoid SNS activation in partner interactions. Therefore, quality sleep allows individuals to be more emotionally regulated and, theoretically, have a more regulated physiological baseline prior to a therapy session.

Stress and Physiology

The body's response to stress can be both protective and debilitating. Activation of the SNS reduces higher-level brain functioning and heightens survival instincts. This activation is primarily suited for life-threatening situations, however, rarely are threats which activate the SNS truly life-threatening (Sapolsky, 1994). The SNS can be activated while working to meet an impending deadline at work, being stuck in traffic, entering a new social situation, or in relationships. Long-term exposure to activation of the SNS can have damaging physical effects (Hermans, Henckens, Joëls, & Fernández, 2014). This system is meant to be activated short-term, enabling the body to protect itself quickly. As a result, when neurotransmitters and hormones related to SNS activation are released, blood pressure, body temperature, breathing frequency, and heart rate increase which prepares the body for survival.

The effects of a stressful event can last up to 24 hours after exposure to stressful stimuli (Herten et al., 2016). In a recent study (Herten et al., 2016), individuals in a stress procedure group were still affected 24 hours after stress exposure and had stronger reactions to startle response procedures than those in a control group. This indicates that the effects of stress remain in the body for as long as a day after exposure to the stressful event. When an individual continues to carry stress hormones in the bloodstream, they are more likely to have a less regulated physiological baseline because they are more prepared for survival responses.

Exercise and Physiology

Exercise provides many important benefits for individual and couple well-being. In recent years, research has illuminated the ideas that "a) physical and psychological well-being are much more tightly linked than once thought and b) romantic relationships are likely important mechanisms and contexts of physical as well as psychological health in adulthood" (Roismann, 2007, p. 39). Additional research indicates that regular exercise is associated with greater well-being, less frequent or less serious anxious and depressive symptoms, and lower rates of psychiatric disorders (Ströhle, 2009).

Consistent exercise also benefits individuals physiologically. When the SNS is activated, physiological sensitivity is heightened, which enhances survival responses. When the body is engaged in high intensity aerobics or interval training, it is experiencing safe exposure to stress. This helps the body expand its stress capacity, tolerate more stress, and recover more efficiently to a physiological baseline (Loehr & Schwartz, 2003; Forcier et al., 2006; Jackson & Dishman, 2006). Exercise may also affect emotional recovery from stressful experiences because consistent aerobic activity fosters resilience against prolonged or excessive emotional reactions (Flueckiger et al., 2016; Kishida & Elavsky, 2015; Ströhle, 2009).

Although exercise has been hypothesized to lead to greater vagal control over heart rhythm (Ekblom, Kilbom, & Soltysiak, 1973), actual research findings have been quite mixed. Many studies indicate that exercisers have a higher resting RSA (Buchheit et al., 2005;

Martinmaki, Rusko, Kooistra, Kettunen, & Saalasti 2006; Shin, Minamitani, Onishi, Yamazaki, & Lee, 1997), while, other studies indicate that those who exercise have a lower resting RSA (Sacknoff, Gleim, Stachenfeld, & Coplan 1994). A recent study examining the relationship between inter beat interval (IBI) and RSA over a 24-hour period found that vagal control is underestimated in individuals with a low heart rate who exercise consistently (van Lien et al., 2011). These findings shed light on the controversial relationship between exercise and resting RSA and suggest that methodological errors may account for the mixed results in the literature. We hypothesize that exercise leads to a higher resting RSA in clients, allowing them to be more physiologically regulated, however, further research is needed in this area.

Current Study

This literature review has suggested that the benefits of sleep, stress reduction, and exercise lead clients to a more regulated physiological baseline. In therapeutic settings, clients who attend therapy with greater physiological regulation are more equipped to emotionally connect to a partner and the therapist, thereby allowing therapy to be more productive and conducive to positive change.

In marriage and family therapy, few studies have focused on the role of physiological functioning as a factor in the change process. Numerous factors contribute to each partner's physiological state, which is very important at the onset of a therapy session. Sleep, stress management, and exercise allow partners to be better regulated physiologically prior to a therapy session allowing easier connection with a partner. The purpose of this study is to examine the effects of sleep, stress, and exercise prior to a therapy session on an individual's physiological baseline. As previously mentioned, this study is unique in the fact that it relies on more objective measures of sleep, stress, and exercise, whereas previous studies have relied solely on self-report. We hope to be able to answer the following research questions:

RQ1. Is a client's lower skin resistance (GSR) baseline related to their sleep, stress, or physical exercise prior to a therapy session? Are there differences in this relationship for a female or a male?

RQ2. Is a client's higher respiratory sinus arrhythmia (RSA) baseline related to their sleep, stress, or physical exercise prior to a therapy session? Are there differences in this relationship for a female or a male?

RQ3. Is a client's higher pre-ejection period (PEP) baseline related to their sleep, stress, or physical exercise prior to a therapy session? Are there differences in this relationship for a female or a male?

We hypothesize that partners in couple therapy who have a higher sleep quality, lower amounts of stress, and exercise prior to therapy will have a more regulated physiological baselines in comparison to partners in couple therapy who have lower sleep quality, higher amounts of stress, and have not exercised prior to therapy.

Method

Sample

The data and participants for this study were part of the Changing Hearts And Minds in relationshiPS (CHAMPS) project, which is currently being conducted at Brigham Young University (BYU). This study uses just some variables and elements of the larger study. For the purposes of this paper, only variables and procedures relevant for this particular study will be described. All participants were clients seeking couple therapy at the clinic associated with the BYU Marriage and Family Therapy program and presented with marital distress. During intake, participants were read a script informing them about the study and were then asked if they were interested in participating. If participants were willing, they received an email with eligibility information. In order to be eligible for the study, participants had to a) speak English; b) be married for at least a year (this period of time serves as a normalization period for a more realistic representation of marital satisfaction); c) be experiencing marital distress according to at least one partner's score on the Couple Satisfaction Index (CSI-4 score of <13.5; Funk & Rogge, 2007); d) be free from any substance abuse problem, any major addictions, or severe mental disorders (i.e. hallucinations, active suicidal ideation, dissociation, etc.); e) be free from conditions that would make receiving a fMRI for research purposes unsafe (i.e. metal implants; pregnancy); and f) be able to participate as a couple. Participants were compensated with a digital copy of their fMRI and $200 each.

Participants were 23 heterosexual married couples who collectively participated in 81 therapy sessions. All but one couple participated in four therapy sessions. The average age of participants was 29.98 (*SD*=5.97; range=22-49). In terms of racial composition, 82.6% of participants identified as White (*n*=38), 8.7% identified as Hispanic (*n*=4), 6.5% identified as Asian/Pacific Islander (*n*=3), and 2.2% identified as Black (*n*=1). Couples had an average of 2.91 children (*SD*=1.66; range=1-6), and average income per family was between $45,000 and $55,000. In terms of education, 8.7% (*n*=4) of participants earned a GED or completed high school, 6.5% (*n*=3) received an Associate degree, 26.1% (*n*=12) received a Bachelor's degree, 4.3% (*n*=2) attended vocational or technical school, 41.3% (*n*=19) attended some college, and 13% (*n*=6) received a Masters or Professional degree. Prior to the start of therapy, the mean score on the CSI-16 was 43.26. Scores below 51.5 suggest notable relationship distress (Funk &

Rogge, 2007). It should be noted that the mean only includes 22 couples as one couple did not take the CSI-16 prior to the start of therapy.

Procedures

Data collection. All procedures were approved by the Institutional Review Board for Human Subjects research at BYU. About a week prior to the first appointment, participants met with a research assistant in a pre-research meeting to collect demographic information and respond to intake questionnaires via Qualtrics (Qualtrics, Provo, UT). During this meeting, participants received ActiLife accelerometers to measure movement (exercise) and sleep. Participants also received a heart rate monitor which synced with the accelerometer to measure heart rate (stress). Participants were instructed to wear both devices daily and complete daily diary self-report questionnaires. They were told they would receive a new link each day for the daily questions via email.

For each of the first four therapy sessions, participants arrived and met with a research assistant who instructed clients on how to place MindWare electrodes on each participant and the therapist (MindWare, 2016). Physiological data were collected using MindWare software and MindWare Mobile Impedance Cardiographs from the participants through electrodes which were wirelessly connected to a computer running the MindWare and Noldus Observer software. These electrodes measured cardiac impedance, skin resistance (GSR), RSA (i.e., vagal tone), and pre-ejection period (PEP). The placement of the respective electrodes was as follows: (1) electrocardiogram (ECG) electrode attached to a positive lead was placed on the bottom left rib; (2) ECG electrode attached to a negative lead was placed on the right collar bone (clavicle); (3) ECG electrode as ground was placed on the bottom right rib; (4) ECG electrode attached to a positive lead was placed on the spine about 1.5 inches above the jugular notch at the vertebral prominins; (5) ECG electrode attached to a negative lead was placed on the spine about 1.5 inches below the xiphoid process; (6) ECG electrode attached to a positive lead was placed on the jugular notch just above where the collar bones meet, set slightly to the right to prevent interference as the subject speaks; (7) ECG electrode attached to a negative lead was placed just below the sternum on the xiphoid process; (8) galvanic skin response (GSR) electrode placed high on the palm of the subject's non-dominant hand, at the thenar eminence; and (9) GSR electrode placed high on the palm of the subject's non-dominant hand, at the hypothenar eminence (Mindware Technologies LTD., 2016). Data were then collected during a period of baseline during in which the therapist, husband, and wife, sat quietly and watched a you-tube video of fish for three minutes.

Therapy sessions. Participants attended four therapy sessions and arrived at each session about half an hour early. This allowed time for a research assistant to help the participants and therapist hook up to the MindWare Mobile Impedance Cardiographs and conduct baseline readings prior to the session as previously described. After baseline measures were taken, a 50-minute therapy session commenced. Data used in this study includes intake data, data from the accelerometers, and physiology data from the baseline period prior to each session.

Dependent Variables

Galvanic skin response; GSR. To capture SNS activation associated with freeze response (citation) we measured for Galvanic Skin Response. Before each session, clients were hooked up to 9 silver/silver/chloride electrodes with the help of graduate research assistants as previously described. These electrodes were connected to the MindWare Mobile device and data were sent to the MindWare software and measured the number of times GSR was activated.

GSR is measured by an increase of sweat in the palms (where the electrode is placed) and in the feet in an effort for the body to cool itself (Martin & Venables, 1980). The mean baseline GSR for males in this study was 4.80 instances of activation with a range of 0-17. For or females the average was 6.19 instances and ranged from 0-41.

Respiratory sinus arrythmia; RSA. To measure parasympathetic nervous system activation, mindware electrodes calculated RSA based on respiration and heart rhythms. This measure indicates vagal tone and vagal reactivity within the PNS and indicates a state of resting, digesting, and connecting (Porges, 2009; Whitson & El-Sheikh, 2003; van Lien et al., 2011). RSA is a direct indicator of heart rate variability (HRV) which measures healthy variations in heart rate (Billman, 2011). As heart rate varies, it is reflected in respiration (RSA) (Billman, 2011). Greater variations in regular heart rate reflect a more regulated physiological state (Sacknoff et al., 1994). Higher resting RSA and HRV indicate greater cardiac vagal control (van Lien et al., 2011) and represent a more regulated physiological baseline. The mean RSA baseline for males in this study was 6.12 with a range of 3.03-9.14. For females, the mean was 6.06 with a range of 3.12-8.34.

Pre-ejection period; PEP. To capture the SNS activation of fight or flight responses, we measured PEP through MindWare electrodes. PEP is the pre-ejection period of blood in the left ventricle in the heart, with the opening of the aortic valve (Newlin & Levenson, 1979) and consists of an electrical-mechanical delay which happens between depolarization and ventricular contraction and represents the total time of the electrical and mechanical events prior to blood ejection (Newlin & Levenson, 1979). As an individual begins starts to experience greater SNS arousal, PEP becomes shorter and shorter. This suggests that a lower PEP is an indication of greater physiological regulation. The mean PEP across the baseline for males was 94.89 with a range of 2-170. For females, the mean was 100.64 with a range of 62-154.

Independent Variables

All independent variables are hypothesized to contribute to an overall physiological baseline for each partner prior to the commencement of the therapy session. All measures for independent variables were analyzed starting when the client went to sleep the night prior to the therapy session.

Sleep. Sleep was measured by a sleep fragmentation index (SFI) and number of awakenings during the night with the accelerometer. This accelerometer provided data to comprise a SFI and it also counted the number of awakenings during the night. Number of awakenings is calculated with the Cole-Kripke algorithm which scores individual epochs as either sleep or non-sleep (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992). Each epoch is scored as either sleep or non-sleep based on a seven-minute window. This window includes the four epochs previous and the two epochs after the current. Any missing epochs are considered 0. If the result of the algorithm is less than one, the epoch is scored as sleep, any value above one is scored as non-sleep (ActiGraph, 2018a). From this data, ActiLife is able to calculate sleep onset, latency, total sleep time, wake after sleep onset, number of awakenings, and sleep efficiency (ActiGraph, 2018a). Sleep fragmentation is an index of restlessness during sleep expressed as a percentage (Knutson, Van Cauter, Zee, Liu, & Lauderdale, 2011). The higher the sleep index, the more sleep is disrupted (Loewen, Siemens, & Hanley, 2009). It is often accompanied by very fast movement (micro arousals) which last between 1-3 seconds (Morrell et al., 2000). SFI is calculated by summing a movement index (MI) and the fragmentation index (FI) (ActiGraph, 2018c). MI is the total of scored awake minutes divided by the total time in bed x 100. FI is the total of 1 minute scored sleep sections divided by the total number of sleep sections of any length x 100. As previously mentioned, measures for sleep were lagged to indicate the night prior to the therapy session.

Stress. Stress was measured by a heart rate monitor paired with the accelerometer. Any time the client's heart rate exceeded 100bpm without exercise (as indicated by accelerometers) was considered an indicator of high stress. On average, when a person's heart rate is above 100 bpm, sympathetic activation of the heart becomes the primary factor in increasing heart rate (Rowell, 1993). This variable was calculated as a percent of time participants experienced high stress before the therapy session.

Physical exercise. Physical exercise was measured with a heart rate monitor paired to the accelerometer. The accelerometers indicated body movement and paired with the heart rate monitors and provided an objective measure of physical activity. Accelerometers also indicated level of physical intensity based on cut points (Freedson, Melanson, & Sirard, 1998). Physical activity was categorized into cut point categories based on a certain number of counts which determined intensity level. These categories of cut points included sedentary, light, moderate, vigorous, and very vigorous activity. Each category indicates the percentage of time an individual participated in that level of activity. Cut points are calculated by using 60-second epoch lengths. Each intensity level has a range of counts (i.e. Sedentary: 0-99 counts per minute (CPM), Light: 100-1951CPM, Moderate: 1952-5724CPM, Vigorous: 5725-9498CPM, and Very Vigorous: above 9499CPM). For more information on how counts are calculated, please see ActiGraph, 2018b. In this study, total percentage of physical exercise is the sum of the proportion of activity in the moderate and vigorous categories. This provided a total percentage of time spent in physical activity starting from when the client went to sleep the night prior to therapy.

Analysis

Data organization. The accelerometer data for each respective independent variable were originally in three separate datasets. Prior to analysis, we merged these datasets, matching them by ID and day. The sleep data was lagged to represent the sleep episode the night before each session. We then conducted an analysis of missing values and found that GSR, RSA, PEP, number of awakenings, SFI, and percent of high heart rate all contained missing data. In order to ensure that there was no bias in the missing data, three chi-square analyses were conducted on the three independent variables to identify if there were differences across sex. The analyses between sexes of number of awakenings ($chi^2(1) = .00, p = 1.0$), SFI (($chi^2(1) = .00, p = 1.0$), and percent of high heart rate ($chi^2(1) = .10, p = .32$) were all found to be not significant. Next, we conducted nine t-tests to determine if the missing data was significantly different between all dependent and independent variables. The analysis of GSR and number of awakenings ($t(160) = .37, p = .71$), GSR and SFI ($t(160) = .37, p = .71$), GSR and percent of high heart rate ($t(160) = -.68, p = .50$), RSA and number of awakenings ($t(159) = .90, p = .37$), RSA and SFI ($t(150) = .90, p = .37$), RSA and percent of high heart rate ($t(159) = -.19, p = .85$), PEP and number of awakenings ($t(160) = .57, p = .57$), PEP and SFI ($t(160) = .57, p = .57$), and PEP and percent of high heart rate ($t(160) = -.66, p = .51$) were all found to be not significant. Because no bias was found, we used 50 imputations to answer all research questions. To fulfill the requirements of the imputation, the data were arranged in a long format. Each therapy session was used as a cluster variable to account for differences across time.

Models. Due to the nested nature of the data three multi-level models were conducted to analyze the baseline GSR, RSA, and PEP for both husbands and wives. The level 1 model was specified to include the following nine covariates as predictors of baseline physiology: session number, moderate exercise time for both partners respectively, SFI for both partners respectively, number of awakenings for both partners respectively, and percentage of the day with a high heart rate for both partners respectively. We used a random intercepts model which allows individuals to start at various places as opposed to a uniform starting place for all participants. Case ID was used as the cluster variable. Each model controlled for sex and session number.

Results

Preliminary Analyses

A correlation table was constructed including all dependent and independent variables (see Table 1). There were a number of significant correlations. Session number was significantly negatively correlated with the wife baseline PEP ($r = -.28$, $p < .05$). Husband baseline GSR was significantly positively correlated with wife baseline RSA ($r = .35$, $p < .01$), negatively correlated with husband baseline PEP ($r = -.27$, $p < .05$), negatively correlated with wife number of awakenings ($r = -.33$, $p < .01$), negatively correlated with husband SFI ($r = -.31$, $p < .05$), and negatively correlated with wife SFI ($r = -.27$, $p < .05$). Wife baseline GSR was significantly positively correlated with husband number of awakenings ($r = .30$, $p < .05$) and positively correlated with wife exercising ($r = .26$, $p < .05$). Husband baseline RSA was significantly negatively correlated with husband SFI ($r = -.25$, $p < .05$). Husband number of awakenings was significantly positively correlated with husband SFI ($r = .30$, $p < .05$). Wife number of awakenings was significantly positively correlated with wife SFI ($r = .50$, $p < .001$).

Husband SFI was significantly negatively correlated with husband exercising (r = -.31, $p < .05$). Husband high heart rate was significantly positively correlated with both wife high heart rate (r = .49, $p < .001$) and wife exercising (r = .25, $p < .05$). Finally, wife high heart rate was significantly positively correlated with both husband exercising (r = .37, $p < .01$) and wife exercising (r = .39, $p < .01$).

Paired-sample t-tests were conducted on each of the dependent and independent variables to identify any meaningful differences in the data based on sex. Males and females were found to be significantly different only in two variables. The PEP baseline for males in the sample (M = 94.89, SD = 23.68) was found to be significantly lower than the PEP baseline for females (M = 100.64, SD = 12.78, $t(80) = -2.12$, $p < .05$). Additionally, males and females were found to be significantly different in their number of awakenings per night. Females were found to have a significantly more awakenings each night (M = 8.59, SD = 4.96) compared to males (M = 6.22, SD = 4.42, $t(45) = -2.58$).

Research Question 1

For the results of all multi-level models, please refer to Table 2. Research question one asked if a client's more regulated SNS baseline, measured by GSR, was related to the client's sleep, stress levels, and exercise prior to therapy. And, if there are differences in this relationship, does it vary by sex? The overall model predicting the number of GSR responses during the baseline was significant (F = (6, 18853.7) 2.37; $p < 0.05$). Additionally, the interclass correlation for this model is ρ= 0.07, which indicates that there is a low amount of similarity between partners. In answering research question one, the only variable that was found to significantly predict total GSR responses was percent of moderate and vigorous exercise (b =17.32; $p < .05$). This indicates that the higher percent of the day spent exercising, the more GSR responses the participant experienced. Finally, there were no differences in response based on session number (*b* = -.04, *p* = .92), or sex of the participant with female as the base category in dummy variable (*b* = 1.06, *p* = 0.24).

Research Question 2

Research question two asked if a client's more regulated PNS baseline, as measured by RSA, was related to a client's sleep, stress levels, and exercise prior to therapy. And, if there are differences in this relationship, does it vary by sex? The overall model predicting the number of RSA responses during baseline was not significant (*F* = (6, 12668.3) 1.32; *p* = .24). This indicates that none of the independent variables used in this model significantly influence baseline RSA. The interclass correlation for this model is ρ = .12 which indicates that there is a low amount of similarity between partners. This would suggest that the clients within a marriage do not influence each other very much.

Research Question 3

Research question three asked if a client's more regulated SNS baseline, as measured by PEP, was related to a client's sleep, stress levels, and exercise prior to therapy. And, if there are differences in this relationship, does it vary by sex? The overall model predicting PEP baseline was significant (*F* = (6, 22139.4) 2.54; $p < 0.05$). Additionally, the interclass correlation for this model is ρ = .09, which indicates that there is a low amount of similarity between partners. This would suggest that the clients within a marriage do not influence each other very much. In answering research question three, the only variable that was found to significantly predict baseline PEP was percent of time with a high heart rate (*b* = -.57; $p < .05$). This indicates that the higher the percentage of the day with a high heart rate, the higher the PEP baseline. Finally, there were no differences in response based on session number ($b = 1.35$, $p = .3$), or sex of the participant with female as the base category in dummy variable ($b = 5.1$, $p = 0.09$).

Discussion

General Discussion

Couple therapy has been proven to be effective in treating marital distress, however, there is still room for improvement in terms of success rates. It is important for research to identify factors that enable client change in the therapeutic setting which lead to greater success. One of the factors which can increase client change is the ability to connect with a partner and therapist in therapy (Anderson & Johnson, 2010). The Polyvagal theory helps us understand how perceived relational threats can activate physiological responses which render clients unable to emotionally connect with a partner or therapist, thereby reducing the couple's ability to progress and foster change in therapy (Porges, 2007; Porges 2009). This study has examined factors, which we hypothesized, may contribute to a more regulated physiological baseline in clients. These factors are sleep, stress, and exercise. Multi-level models were conducted to identify the impact of sleep, stress, and exercise on GSR, RSA, and PEP which are three indicators of physiological baseline.

Preliminary analyses revealed that women tend to have a higher PEP baseline compared to men. This finding might suggest that women are more physiologically regulated in terms of SNS responses. It is possible that a more regulated SNS baseline indicates that women are less likely to engage in fight-or-flight behaviors compared to men (Taylor et al., 2000; Turton & Campbell, 2005). Additional preliminary analyses revealed that women have a higher number of awakenings during the night. As the majority of the sample are fairly young and are parents, it is likely that the number of awakenings for wives in this study is related to waking up in the night with small children. Other research supports this finding as some studies indicate women experience significantly more sleep disturbance in comparison to men (Zheng et al., 2018).

Correlational analyses also revealed that both husband and wife GSR were significantly correlated with several other variables. Husband GSR was positively correlated with wife baseline RSA and negatively correlated with husband baseline PEP. This indicates that as the wife's RSA baseline becomes more regulated, the husband's GSR baseline becomes less regulated. Additionally, it indicates that as a male's GSR baseline becomes more regulated, his PEP baseline becomes less regulated, contrary to what we would expect. Husband GSR is also negatively correlated with independent variables measuring sleep. Husband GSR is negatively correlated with wife number of awakenings and both husband and wife SFI. Contrary to what we would expect, this would suggest that a male's physiological baseline related to GSR becomes more regulated the more his wife's and his own sleep is disrupted. Wife GSR baseline is also significantly negatively correlated with her husband's number of awakenings, suggesting that as her husband has more awakenings per night, her GSR baseline becomes more regulated. Wife GSR baseline is also positively correlated with her percentage of time exercising, suggesting that her GSR baseline becomes less regulated as she increases exercise. All of the significant correlations related to GSR in this study are the opposite of what we would expect. Additionally, the time period of measurement could significantly influence these variables. These errors will be discussed in greater detail in the limitations section of this paper. Finally, husband baseline RSA was significantly negatively correlated with his own SFI, suggesting that as his RSA baseline becomes more regulated, his sleep becomes less disrupted. This finding is in harmony with our hypothesis and is likely because sleep allows an individual to experience a higher stress threshold while remaining physiologically regulated (Flueckiger et al., 2016).

Research question one examined the effects of sleep, stress, and exercise on GSR baseline measuring SNS activation of freezing (behavior inhibition) responses. Percentage of time exercising was the only variable found to significantly predict GSR baseline. However, our findings were opposite of our hypothesis. The more clients exercised, the more GSR baseline increased thereby decreasing client physiological regulation. This finding is difficult to explain, however, upon further analysis of our data, we identified three significant outliers of female baseline GSR. The mode number of GSR microsiemens among females was 0, indicating that before many sessions, some women had minimal activation. It is possible that these outliers may have inflated GSR baseline, making it difficult to understand the true relationship of our independent variables with this measure of baseline.

Research question two examined the effects of sleep, stress, and exercise on RSA baseline measuring PNS activation. Contrary to our hypothesis, none of our independent variables significantly predicted baseline RSA. While most literature supports the idea of increased RSA with exercise (Buchheit et al., 2005, Martinmaki et al., 2006, Shin et al., 1997), not all research supports this idea (Hatfield et al., 1998; Goedhart, de Vries, Kreft, Bakker, & de Geus, 2008). This would suggest that there could be methodological problems in measuring RSA accurately (van Lien et al., 2011). It is possible that some methodological errors relate to the period of recordings (van Lien et al., 2011). A review of a meta-analysis of training studies indicated that an exercised-induced increase in HRV and RSA is not consistent over a 24-hour period (Sandercock, Bromley, & Brodie, 2005). Another study indicates that an increase in HRV and RSA, due to training effects, was present during daytime readings but absent throughout the entire ambulatory recording and nighttime periods (Schuit et al., 1999). This may suggest that the effects of an increase in baseline HRV or RSA may not stay consistent through a

24-hour period. If clients in our study came in for an evening appointment, it is possible that their baseline RSA could have been different from right after a workout. An additional study indicates that even a seven-week training period was not found to significantly reduce reactivity or recovery of HRV and RSA (de Geus, van Doornen, de Visser, & Orlebeke, 1990). This suggests that more extensive training might be required to significantly reduce RSA baseline in clients Therefore, if clients do not exercise consistently, it is possible that exercise may not significantly decrease RSA baseline.

Research question three examined the effects of sleep, stress, and exercise on PEP baseline measuring SNS activation (fight-or-flight). Our analysis revealed an inverse relationship between the stress percentage of the day and PEP. This indicates that as an individual has more daily stress, they are experiencing greater SNS arousal indicated by PEP baseline. This finding is consistent with our hypothesis that daily stress significantly predicts a less-regulated physiological baseline for couples in therapy. As daily stress increases, the SNS becomes activated to prepare the body for survival (Sapolsky, 1994). Because stress triggers SNS responses, it would make sense that as stress increases, SNS arousal also increases. This is highlighted by our finding that a higher percentage of daily stress would be associated with a higher baseline PEP.

Clinical Implications

Our preliminary analyses revealed some important gender differences which have important clinical implications. First, we found that women have a significantly lower PEP baseline compared to men. It's possible these findings would indicate that women are less likely to become as physiologically reactive or that they might take longer to become physiologically reactive. This is important for therapists to understand as they are working with couples.

Therapists may find that they are having to help men emotionally regulate when reactive more often than female clients. Another significant gender difference in our findings is that females had more frequent awakenings during the night. As therapists work with clients who experience disturbed sleep, it is important they recommend a lower caffeine intake, regular nighttime routines, and possibly suggest visiting with a physician as frequent awakenings during the night can be an indicator of sleep apnea (Loewen et al., 2009).

One of the most important findings from this study was the relationship between daily stress and SNS baseline. As clients experience an increase in daily stress, they are more likely to become physiologically aroused through the activation of SNS responses, which may prevent the emotional connection experienced when the PNS is primarily in control. If clients are not in a physiological state conducive to emotional connection in therapy, they may be less likely to progress and experience change. Therefore, it is critically important for therapists to encourage clients to engage in practices outside of therapy which allow them to reduce or maintain a low level of stress.

One of the ways clinicians can help clients reduce stress is through mindfulness-based interventions and teaching mindfulness practices. Research indicates that mindfulness practices have been shown to reduce daily stress levels in clinical (Goldberg et al., 2018; Segal, Williams, & Teasdale, 2012; Bowen, Chawla, & Marlatt, 2010) and non-clinical samples (Khoury, Sharma, Rush, & Fournier, 2015). Both formal and informal mindfulness techniques have been found to decrease daily stress (Kabat-Zinn, 2013). More formal mindfulness practices, like meditation, can be taught or used as a therapeutic intervention. Therapists can also encourage clients to participate in less-formal mindfulness practices such as short breathing exercises, grounding body scans, and finding moments of gratitude. As therapists help clients integrate mindfulness practices into daily life, clients will be able to lower daily stress (Kabat-Zinn, 2013; Goldberg et al., 2018; Khoury et al., 2015), and subsequently lower SNS activation. Doing so will allow clients to connect more easily to a spouse and partner and foster greater progress and change in therapy.

Limitations and Future Research

There are a number of limitations in the current study and we suggest that future research address these limitations and add to the literature focused on the effect of sleep, stress, and exercise on client physiology and therapeutic processes. We would like to acknowledge factors which may have limited our ability to fully understand this effect, these include 1) the time period of accelerometer readings which were analyzed and 2) the limited number of participant dyads.

For the purposes of this study, we chose to analyze accelerometer readings indicating sleep, stress, and exercise starting from when the participant went to bed the night before the therapy session. Clients who had a morning therapy session might have contributed only minimal data (in terms of stress and exercise) due to the time of their appointment. This suggests that clients who had the most data were those whose therapy sessions were later in the evening. This would exclude exercise readings for individuals who choose to exercise at night. Ideally, future research should focus analyze data starting 24-hours prior to the therapy session.

Additionally, although the sample for this study was 81 days, the population for this sample was relatively small, which possibly lowered the external validity of this study. The sample consisted of 46 individual participants (23 dyads). This was also a fairly homogeneous population (predominantly White/Caucasian; early 20's) which may reduce generalizability. It is unclear if the characteristics of this population have influenced the results, however, it is possible. We recommend that future research should use a population of at least 30 dyads with greater age and racial diversity.

Finally, both, the GSR and PEP data for this study contain significant outliers. With GSR data specifically, because GSR baseline was measured as the number of times GSR was activated, it is possible that GSR could have been activated during each breath for some clients. The outliers in the data could influence the significant findings related to daily stress and PEP, therefore, we suggest that these findings be interpreted with caution.

Conclusion

The purpose of this was to understand the influence of sleep, stress, and exercise on client physiological baseline prior to a couple therapy session. Using the Polyvagal Theory to guide this study, we hypothesized that sleep, lower stress, and exercise would contribute to a more regulated physiological baseline prior to a couple therapy session. Results indicated that exercise significantly increases baseline GSR which suggests that exercise decreases regulation related to GSR. Neither sleep, nor stress and exercise significantly predicted RSA baseline. Finally, daily stress was found to significantly predict a more regulated baseline related to PEP. We believe these results indicate that reducing daily stress will contribute to a more regulated physiological baseline. We suggest that therapists work with clients to reduce daily stress to create a more regulated physiological baseline. Additionally, we suggest that future research would take these findings a step further and explore how sleep, stress, and exercise influence in-session client physiological responses and thereby influence the course of therapy.

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Table 1

Intercorrelations between all dependent and independent variables.

	1	2	3	4	5	6
1. Session Number	--					
2. Husband GSR	.05	--				
3. Wife GSR	-.08	.00	--			
4. Husband RSA	-.02	-.09	-.08	--		
5. Wife RSA	.02	.35**	.09	-.16	--	
6. Husband PEP	.15	-.27*	-.03	.10	-.03	--
7. Wife PEP	.08	-.07	-.19	.13	-.11	.21
8. Husband Number of Awakenings	-.06	.09	.30*	-.09	.10	-.02
9. Wife Number of Awakenings	.05	-.33**	.12	-.16	.15	.17
10. Husband SFI	-.03	-.31*	.06	-.25*	.02	-.21
11. Wife SFI	.22	-.27*	-.09	.03	-.09	.22
12. Husband High Stress	-.16	.20	-.01	-.21	.16	-.21
13. Wife High Stress	-.28*	.13	.15	-.14	-.02	.03
14. Husband Percentage Exercising	.04	.18	-.10	.07	-.04	.11
15. Wife Percentage Exercising	-.02	.01	.26*	.05	.08	-.06
M (SD)	2.4	4.8 (3.95)	6.19 (7.14)	6.12 (1.40)	6.06 (1.01)	94.89 (23.68)
t-values	--	-1.52	-1.52	.28	.28	-2.12
t-test DF	--	80	80	79	79	80
Range	1-4	0-17	0-41	3.03-9.14	3.12-8.34	2-170

p<.05, p<.01**, p<.001****

7	8	9	10	11	12	13	14	15
--								
.05	--							
-.34	.12	--						
-.08	.30*	.08	--					
-.05	.10	.50***	.11	--				
-.08	.11	.08	.04	-.00	--			
-.18	.16	.19	-.10	-.05	.49***	--		
.15	-.03	.01	-.31*	-.09	.15	.37***	--	
.01	.07	.01	-.11	-.25	.25*	.39**	.16	--
100.64 (12.78)	6.21 (4.42)	8.59 (4.96)	26.64 (20.70)	25.25 (12.84)	2.79 (8.46)	1.96 (5.08)	.06 (.06)	.05 (.06).
-2.12	-2.58	-2.58	.44	.44	.86	.86	.98	.98
80	45	45	45	45	58	58	80	80
62-154	0-14	0-20	0-88.09	.90-51.98	0-48.33	0-26.39	0-.27	0-.29

Table 2

Multilevel model of baseline physiology for couples prior to therapy.

	Coef.	*Std. Err.*	*t*	*P>t*	*95% Confidence Interval*	
GSR						
Session	-.04	.40	-.10	.92	-.81	.73
Female	1.06	.90	1.17	.24	-.71	2.83
Percentage Exercising	17.32	8.14	2.13	.03*	1.37	33.28
SFI	-.06	.03	-1.48	.139	-.11	.02
Number of Awakenings	.16	.11	1.52	.13	-.05	.38
High Heart Rate	.06	.08	.75	.46	-.09	.21
_cons	4.03	1.56	2.59	.01**	.98	7.08
RSA						
Session	-.05	.09	-.54	.59	-.22	.12
Female	-.13	.20	-.62	.53	-.52	.27
Percentage Exercising	.93	1.83	.51	.61	-.2.64	4.51
SFI	-.01	.01	-.1.95	.05	-.03	.00
Number of Awakenings	.03	.03	1.02	.31	-.02	.08
High Heart Rate	-.03	.02	-1.72	.09	-.06	.00
_cons	6.40	.35	18.15	.00***	5.71	7.09
PEP						
Session	1.35	1.29	1.05	.29	-1.18	3.88
Female	5.08	2.99	1.70	.09	-.78	10.94
Percentage Exercising	23.40	26.92	.87	.39	-29.37	76.17
SFI	-.17	.10	-1.67	.10	-.36	.03
Number of Awakenings	.11	.37	.29	.78	-.61	.83
High Heart Rate	-.57	.25	-2.28	.02*	-1.05	-.08
_cons	95.19	5.14	18.51	.00***	85.11	105.27

p<.05, p<.01**, p<.00*