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**The Role of Physiological Regulation and Mindfulness in Youths' Mental
Health**

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*“Simplicity means going fewer places in one day rather than more, seeing less,
so I can see more, doing less so I can do more, acquiring less so I can have
more”- Jon Kabat-Zinn*

*To My Grandparents, who were and are my most precious example of simplicity
and love; Nonno Tonino, Nonna Mery, Nonno Gianni e Nonna Marina.
(Dedicato ai miei nonni, che erano e sono il mio esempio più prezioso di
semplicità e amore.)*

*And to my parents who show me every day how much simple love can make a
difference. (E dedicato ai miei genitori, che mi mostrano ogni giorno come il
semplice amore possa fare la differenza.)*

Abstract

In a world where life keeps going faster and faster, mental health is becoming a key problem in society, especially in adolescents. The present study addresses this issue and investigates the correlation between mental health, emotion regulation as cardiac vagal tone (CVT), and mindfulness trait in pre-adolescents. Previous research shows the impact that emotion regulation, more specifically CVT has on mental health, but not much is known about the connection with mindfulness trait especially in pre-adolescents. This study tries to fill this gap with the aim to provide better understanding of how these correlations are established, the pre-adolescents' emotional awareness, and the interactions between these variables. The study was conducted in a middle school in Italy (11-13 years old), emotion regulation as CVT was measured using heart rate variability, mental health using the SDQ and mindfulness trait with the CAMM joined with a qualitative measure. Results showed that pre-adolescents' emotional awareness was low; moreover, a negative correlation was found between mindfulness trait and emotional problems and CVT at rest and emotional problems. No correlation was found between mindfulness trait and CVT at rest. A gender difference was also found in CVT at rest and mental health, while no difference in mindfulness trait. Finally, a three-way interaction was found between CVT at rest, mindfulness trait and gender. In conclusion, these findings fill a gap in literature by focusing on pre-adolescents, and measuring their mindfulness trait, CVT, mental health, and their relationships, all in one study.

Moreover, it can contribute to research with the results on gender difference and with the used methods like heart rate variability as physiological measure for emotion regulation, and both quantitative and qualitative measures of mindfulness.

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Chapter 1

Mental health during middle school: what do we know?

1.1 Defining Mental Health

Mental health is a crucial aspect of everyday life, and it influences every single human being differently. Nowadays awareness toward staying healthy not only physically but also mentally has grown significantly. This is thanks to the many scientists that have worked towards providing better definitions, explanations, and solutions to problems that affect our mental health. Mental health has become very important not only for the individuals in need, but also for our societies and communities. Here we will provide an overview of the current research and findings on mental health in general. Firstly, explaining the burden of mental health, defining it, and covering its key aspects. Subsequently, exploring and understanding the main factors that affect mental health, as well as what can be done to improve it. Lastly, the implications that mental health has on humans will be explored.

Recent findings show that 1 in 5 adults suffers from a mental health disorder (National Institute of Mental Health [NIMH]). This shows the huge impact that mental health has on our lives nowadays. Before understanding more about the factors that can influence mental health and what can be done, there needs to be a universal understating of what mental health is specifically. In scientific research, mental health is considered a condition, and in order to achieve this condition a group of symptoms at a certain level needs to coexist for an extended duration of time and influence social and brain functioning (American Psychology Association [APA], 2018; Snyder & Lopez, 2001).

Nevertheless, it is hard to find literature that talks about a universal and only form of mental health. This is because mental health includes many aspects and factors, and it is also very subjective. For this reason, to understand every facet of it, researchers usually need to operationalize mental health, studying the symptoms, which can help them understand, study, and analyze it better. In the past, theorists Ryff and Keyes (1995) who conducted many studies on this topic suggested that positive functioning and well-being have a six-factor structure: self-acceptance, positive relations with others, personal growth, purpose in life, environmental mastery, and autonomy. More recent models propose a three subcategories structure: emotional well-being, social well-being, and psychological well-being (Snyder & Lopez, 2001). It has been highlighted though, that each of these categories includes many dimensions. For instance, the emotional well-being of an individual means understanding the life satisfaction, the feelings, and the emotional states of that person. Instead, social well-being includes investigating the individual's social relationships, social integration, and family and peer networks. Lastly, scientists look at the psychological well-being which can be referred to as investigating perceptions of reality and personal growth (Snyder & Lopez, 2002). Therefore, mental health can be defined as the union of social, emotional, and psychological well-being that affects the way we act, think, and feel (Substance Abuse and Mental Health Services Administration [SAMHSA], 2023).

As shown before, as there are many aspects that define mental health, there is no single cause of mental health disorders, like there is no single factor to promote and maintain mental health. Research shows that the main factors that affect mental health can be divided into these categories: biological, environmental, psychological, social, and cultural (SAMHSA, 2023). The most widespread and influential model within

psychological research is the biopsychosocial model which suggests that the main factors affecting mental health are biological, social (environmental), circumstantial (life events), and psychological (Engel, 1977). Biological factors include for example brain chemistry, sleep, and genetics. Much research shows how hormone imbalances, different structures of the brain and transmitted genetics are related to mental health (Bennett & Lagopoulos, 2015; Blows, 2021; Fernandez-Jaen et al., 2015). Furthermore, environmental factors include aspects like the neighborhood where an individual grows and lives, school settings and family. For example, studies show that people who grow up and live in environments that have high crime, high poverty, family instability and low hygiene are more likely to have poorer mental health (Ross, 2000; Nikulina et al., 2011; Hendryx & Ahern, 1997). In addition, there are studies that highlight that high levels of pollution and accessibility to green areas impact mental health (Dales & Cakmak, 2016; Kim & Kim, 2017). Moreover, it has been suggested that also family history of mental health problems has an impact on the development of a mental health disorder (Qin et al., 2002; Grant & Chamberlain, 2020). Regarding psychological factors, literature has shown that they also have an impact on mental health. Studies show that specific personality traits, anxiety, self-perception of identity and different thinking styles affect mental health (Dohrenwend, 1975; Nolen-Hoeksema et al., 2008). In addition, sociological perspectives and psychological studies suggest that it is not only the personal and the brain characteristics that influence the mental health of an individual, but it also depends on the social situations that they have to face (Horwitz, 2010). For instance, life events which are particularly stressful, like the loss of a loved one, abuse, trauma, or a divorce; and the more often one is exposed to those, the worse mental health will be (Stansfeld et al., 2006). Lastly, when talking about the cultural

factor, this refers to the religious and cultural beliefs, societal rules and political beliefs that live within a community or society (Hwang et al., 2008). For example, if a culture holds stereotypes around specific mental health problems or regimes, or if there is stigma around mental illness, and the accessibility to treatments and support (Horwitz, 2010; Hajak et al., 2021).

Therefore, when analyzing mental health, multifaceted dynamics need to be examined, not only considering the individual clinically, but all the broader implications surrounding her/him, like the community and society where she/he lives. Over the years psychologists have found a way to investigate mental health, using questionnaires and scales with quantitative and qualitative measures adherent to each aspect and dimension, and which make the study of mental health easier, standardized, and universal (APA). Using these scales, it is important to highlight that in contrary to what many used to think, mental illness and mental health are not two opposites of the same continuum. This means that finding low scores of mental health does not imply mental illness. Mental health is a complete state, this means that to be true, there needs to be an absence of mental illness but also the presence of high-level mental well-being (Snyder & Lopez, 2001).

From all the previously mentioned studies, it has been shown how much mental health can be affected by many factors. The disruption of mental health can have implications on our everyday lives, starting from how we think, feel, and behave (NSW Health, 2022). Research shows implications on individual functioning, interpersonal relationships, and work productivity (Bruffaerts et al., 2018; Stewart-Brown, 2005). Moreover, they highlight a negative impact on physical health, lower life satisfaction and poorer quality of life (Schlack et al., 2021; Lindeboom et al., 2002). For this reason,

psychologists and researchers have suggested coping strategies and resources to maintain good mental health (Lazarus, 1984). These strategies can help minimize the problems, manage them, master them, and/or tolerate them, fighting the factors that were mentioned before, for example a poor environment (Lazarus, 1978). Therefore, establishing healthy coping strategies and lifestyles in an environment that promotes this, is very important in order to avoid developing mental health disorders and to lead a happier life.

A last point which is important to mention when talking about mental health is gender. Research highlights that gender also plays an essential role in mental health. Many studies in the past have suggested the high difference in mental health and vulnerability in females compared to males, calling it the “gender gap” (Prior, 1999). Previous studies show higher rates of psychiatric symptoms and higher numbers of admissions into hospitals and psychiatric centers in women compared to men (Prior, 1999). However, more recent research highlights how in the previous articles there is some bias since they used to only focus on studies with males participants and with also low validity since they did not include disorders like substance abuse and personality disorders in the research (Prior, 1999; Rieker et al., 2010). Instead, looking at more recent studies that include behavioral disorders like substance abuse, violence, and personality disorders, males show equal, if not greater susceptibility compared to women (Robins, 1991; Kessler et al., 1994). While if we concentrate on disorders like depression and anxiety, they are more frequent in women (Seedat et al., 2009; Kessler et al., 1994). Therefore, three hypotheses have been concluded which have been now widely accepted. Firstly, that females and males have similar to equal rates of psychopathology. Secondly, they differ in their expression, with females displaying

more affective disorders like depression and anxiety, while males show more behavioral disorders like substance abuse and antisocial personality disorders. Lastly, females are more likely to respond to stressful events with affective problems, while males with behavioral problems (Hill & Needham, 2013). The same has been shown to be true in studies conducted with adolescents (Ostrov et al., 1989) however, since this is such a delicate period of time, there are additional factors that come into play, and this is going to be discussed further in the next chapter.

1.2 Mental Health in Adolescence

Although as it has been mentioned mental health in general has been shown to be an increasing problem, according to the World Health Organization (WHO) 13% of the mental health disorders in the world are in adolescents (WHO, 2021). These are striking numbers which make scientists wonder why, and what can be done to change this. This is important at the individual level for each youngster's health, but also globally, because the adolescents of today will be the future of tomorrow, which therefore everyone wants to preserve and protect.

Many empirical studies show how adolescence is a critical period for an individual's mental well-being. This is because during this particular time, adolescents learn social and emotional habits, which will affect the individual's mental health both in the present and in the future (WHO, 2021). In addition, adolescents are more sensitive and fragile to mental health problems, and this is caused by many factors and changes at the biological, social, and psychological levels (SAMHSA, 2023).

Firstly, looking at the more biological and physiological aspects, puberty is a very sensitive period in adolescents' lives. It is characterized by a mix of hormones'

imbalances, which make all life experiences feel like a rollercoaster. Many studies have demonstrated for many years, the strong association between hormones and mental health problems like depression, anxiety, eating disorders and delinquent behaviors (Latif, 2022; Patton & Viner, 2007; Giedd et al., 1999). Moreover, to support this, research shows that there is a significant increase in depression in adolescents compared to children, 25% (Kessler et al., 2001). This is because, as Walker et al. (2004) showed, during puberty adolescents go through hormonal changes which affect the brain, and as a consequence affect their behaviors. These behaviors are usually adjustments to overcome the changes that the body is going through, however, sometimes they lead to maladaptive behaviors which then lead to poor mental health. Furthermore, because during puberty teenagers go through these hormonal imbalances, it has been suggested that the pubertal age start (maturational deviance hypothesis), and the menstrual cycle in females are highly associated to mood swings, high stress, and adjustment problems (Susman et al., 2003; Caspi & Moffitt, 1991; Latif, 2022). Therefore, looking more closely at the specific hormones that cause the big changes not only at the physical level, but also emotionally and psychologically during puberty, scientists concluded that they are: testosterone, estrogen, cortisol, and DHEA (Latif, 2022; Susman et al., 2003). More specifically testosterone increases the likelihood of aggressive behavior, estrogen has been linked to more calming behaviors, cortisol has been shown to prepare the body for fight or flight, therefore alert, and DHEA has been linked to mental health like depression and anxiety (Susman et al., 2003). In summary, there is a mix of findings, however they all show that there is a relation between hormones during puberty and mental health. However, literature argues that it is not only a fact of hormonal levels, because they account only for the 6% of impact on emotions. Instead, it has been

suggested that other factors like personality traits and contextual characteristics play an essential role with hormones, to affect mental health in teens (Susmann, 1997).

Therefore, looking at the contextual characteristics, it has been suggested that the mental condition in teens can be influenced by factors like socio economic status, exposure to poverty, violence, traumas, and abuse (WHO, 2021; SAMHSA). Research shows how teenagers have high environmental sensitivity, therefore early adversities during development like a stressful or neglectful environment, can lead to social and psychological problems. For example, being exposed to stressful life events like traumas, family conflicts or abuse can lead to depression and drug problems (Scrimin et al., 2018; Brook et al., 1989; Lewinsohn et al., 1998). In addition, to support this hypothesis, research shows that having an environment with a high-level structure, healthy social opportunities, conventional values and nondeviant peers, lead to less antisocial behavior (Choice, 2003). This suggests that the environment where a teenager grows and the exposure to certain situations, do affect their mental health.

Moving onto the social aspects that might affect an adolescent's mental health, other studies show the impact of social relations in the family network and within peers. Adolescence is a cross over time where teenagers go from relying completely on their parents, to wanting to be independent and valuing parental relationships less and turning more to look for peers and romantic relationships (Richard et al., 2003). Therefore, it is a delicate period of time in the family network, since even though teenagers feel and act differently, parents still play a crucial role in their development. This has been demonstrated in many studies where low parental communication, low parental care and support, and feeling unable to talk to their parents about decisions or problems, has been shown to be highly correlated to unhealthy weight control behaviors, depression,

substance use, suicide, and low self-esteem (Ackard et al., 2006; Johnson & Galambos, 2014; Colarossi & Eccles, 2000).

In addition, adolescence is a crucial period for peers and romantic relationships, and since they are full of ongoing hormonal changes, as it has been shown before, they experience these relationships amplified at the maximum level (Choice, 2003). They can be positive, since new friendships and peers' networks can increase support, cooperation, approval, and a time for sharing ideas (Choice, 2003; Dishion et al., 1994). However, during this sensitive time, where teenagers experience many social networks around them, like school, sport teams and after school activities, there are social situations which create which can bring many emotions and feelings on the surface. In a peer network adolescents need to gain a peer status (popular, unpopular, controversial, neglected or rejected) and these situations of ingroup-outgroup have been shown to be closely linked to the teenagers' individual behaviors, school dropouts, delinquency, and mental health (Choice, 2003; Cardinu & Kiesner, 2000; Dishion et al., 1994). Moreover, these peer networks can lead to a chain of other problems, especially since this is a time where teenagers are more sensitive to others' judgement. There are many stereotypes and therefore they feel more peer pressure, the pressure to conform, and this many times leads to even more difficult situations like bullying (Juvonen & Galvan, 2008). In addition, studies show that because of these reasons, young people are reluctant to seek professional help for mental health problems (Rickwood et al., 2007). This creates a problem in itself, since it means that having a problem or a disorder is considered a taboo, and teenagers do not speak about it freely. Indeed, all social aspects like the stigma around a disorder, the isolation in school and from friends, stereotypes, exclusion, and discrimination; they can all lead to misdiagnosis, not seeking help,

educational difficulties, and risk-taking behaviors, which will only make the disorder more persistent (WHO, 2021).

It also needs to be considered that adolescence is a crucial period for personal growth, academically, humanely, and professionally and therefore psychologically demanding. This means full of important decisions about one's identity, who they want to become in the future, what school to go to and all the responsibilities that build up as teenagers grow older (Richard et al., 2003). This can significantly impact teenagers' mental health and general well-being since it can cause stress, high self-evaluation, low self-esteem, and anxiety (Eccles et al., 1999). Therefore, as shown, there are many factors that influence mental health in adolescents, and which make them more vulnerable. It is therefore essential to prevent and intervene on their mental health to help them make their way into the world and move into adulthood.

Now going back to the "gender gap" previously mentioned, as said, this is shown also in adolescence. From all the factors that have been introduced in this chapter that affect adolescence, we can understand better why and how hormonal changes and social roles affect males and females differently. More deeply, studies investigated the gender difference in teenagers in emotional, behavioral difficulties, peer problems and subjective well-being and looked the different developmental trajectories. In general females show higher emotional difficulties and subjective well-being and this keeps increasing as they grow older, while it was found that for males this is lower and it stays stable over time (Yoon et al., 2023). This is in line with what was previously mentioned since females are more likely to display emotional symptoms like depression and are more vulnerable due to the pubertal timing. Moreover, it was found that boys show more behavioral problems compared to girls, which is also in line with previous

research. However, as years go by, girls reach the boys also in the behavioral problems (Yoon et al., 2023). More studies highlight the difference in timing, with boys showing more psychological distress when they are older, in the latter stages of adolescence (20-25 vs 15-19 y.o.), while for girls it is already high, and higher than boys, in the first stages of adolescence (Van Droogenbroeck et al., 2018). Lastly, social roles and peers as we have seen play an essential role in adolescence and they affect boys and girls differently in their mental health. It has been found that there is a high correlation between peer confirmation, social support, and mental health in girls, while this was not found in boys (Schraedely et al., 1999). In addition, girls report more social stress and pressure than boys, which are strongly correlated with health complaints and anxiety (Wiklund et al., 2012). In summary, these findings are in line with what previously discussed, females experience mental health differently from males, due to different pubertal time and hormonal changes. For this reason, boys also experience mental health difficulties later in their developmental trajectory. Moreover, as suggested boys show distress more with behavioral problems, while girls with emotional problems. Finally, in line with the hypotheses previously mentioned, boys and girls both show distress, however this can happen at different stages of adolescence, and it can be displayed in different ways.

Chapter 2

Emotion Regulation

2.1 What is Emotion Regulation?

Emotions are continuous states that we experience as biological responses to the perception of the environment. Emotions are essential for the human functioning and therefore it is important to know and understand how to regulate them in the best possible way (Gross, 1998). Regarding how to regulate emotions, psychologists used to believe that emotion regulation (ER) was based on a stimulus-response mechanism, this means that when a stimulus is perceived, an emotion responds. However, it is now clear that it is more complex than that. ER can be said to be the sum of conscious and unconscious mechanisms and strategies used to increase, maintain, or decrease an emotional response, used to adapt to the present environment and context (Gross, 2013). ER can be addressed and researched both as a process and as an outcome; ER as outcome means looking at how and how much one displays their emotions and controls them. For example, one can investigate ER by looking at emotion lability, maladaptive emotional reactions, and negative moods (Gross, 2013). Instead, if focusing on the process aspect, it is how an individual deals with a situation and emotions, therefore the coping strategies employed and also the attempt to stimulate positive emotions (Gross, 2013).

The emotion regulatory processes have been studied for a long time and following Gross's Modal Model of emotions, they require the ability to select relevant stimuli from the environment based on the goals, using selective attention to inhibit

irrelevant information, analyse and assess the situation always based on the goals, and then respond (Miller & Thayer, 1988; Gross 2013). Gross suggested that ER has three core features, firstly, the activation of a goal to modify the emotion generation, then the engagement of the processes that alter the emotion trajectory (implicit or explicit), lastly, the impact on emotion dynamics (Gross, 1998). Gross also proposed a model on emotion regulation which comes from how emotions are generated and it is the Process Model (Gross, 1998). The model has 5 different main emotion regulatory processes: situation selection, situation modification, attentional deployment, cognitive change, and response modulation (Gross, 1998). At different processes are associated different strategies, Ochsner and Gross (2005) have identified two main categories: behavioural regulatory strategies, and cognitive strategies. Cognitive strategies rely more on attentional control, therefore moving the attention onto something else to regulate emotions, and cognitive change. For example, the most well-known form of cognitive change is reappraisal, which means changing the way we think about a situation to change our emotions about it. Another much researched strategy is suppression, which is a behavioural strategy for response modulation, it means when an individual hides emotional-expressive behaviour (Gross, 2013). Different types of ER have different behavioural, cognitive, and emotional consequences, both in the short and long-term. In addition, all these different strategies take over at different time points of emotion regulation and can be used to up-or-down-regulate emotions according to the goals. The processes involved can be (bottom up) implicit, so unconscious and automatic, or (top down) explicit, therefore conscious, and voluntary (Gyurak et al., 2011; Guendelman et al., 2017).

Moreover, when looking at ER, individual differences need to be considered, as a stressor can affect differently each individual, and this is because there are different ways of coping with life events, external and internal stimuli (DeSteno et al., 2013; Lazarus, 1993). Furthermore, as mentioned before, emotions are responses to the perception of the context around us, therefore each individual's perception can differ, depending on goals, needs, cognitive and emotional functioning (Gross, 2013). Subsequently, based on the context and the emotions, a sequence of behavioural mechanisms is initiated which are calibrated accordingly (Timberlake, 1994). Therefore, it is important to analyse an individual's ability to regulate their emotions because this will impact their behaviours (Frijda, 1988).

2.2 Cardiac Vagal Tone

When talking about ER many researchers have tried to investigate the neural and physiological mechanisms behind it, four main theories have been suggested, all highlighting a link between the heart and ER. More precisely they call this the Cardiac Vagal Tone (CVT). The vagus nerve is the main nerve of the parasympathetic nervous system, it connects face, heart, and body and it has been suggested to be at the center to allow the body to find the balance it needs to function properly (homeostasis). The first theory proposed by Thayer et al. (2009) is the neurovisceral integration model, and it is based on the assumption that the prefrontal cortex and the heart are connected through the vagal nerve. They suggested that the higher CVT, the better cognitive functions and ER. Subsequently the biological behavioral model (Grossman & Taylor, 2007) has been proposed which highlights how the CVT is needed to coordinate respiratory and cardiac mechanisms when an individual is adapting, thanks to the monitoring of energies

exchanges between those systems. They suggested that higher CVT is therefore related to higher energy synchronization between the systems and therefore higher adaptability. Then the psychophysiological coherence model (McCraty & Childre, 2010), which also following Lehrer (2013) suggestion, hypothesizes that slow paced breathing is connected to the increase of CVT and that slow breathing with positive emotions will lead to many positive outcomes, emotionally, socially, and psychologically. Lastly, the Polyvagal Theory (Porges, 2001), which is what this paper is going to focus on. Porges proposed this theory based on the Autonomic Nervous System (ANS) of mammals when they enter the survival mode of fight, flight or freeze behavior. He suggested that humans have the ability to switch from defensive to prosocial behavior by inhibiting these basic neural mechanisms. He also proposed that the parasympathetic system is linked to the vagal nerve which regulates the cardiac activity and the ability to adapt and that it can be seen through the CVT. Looking at this more deeply, the heart is in fact highly influenced by the vagal nerve, through the myelinated pathways connected to the sino-atrial node (Porges, 2007). For example, he suggested that vagal withdrawal would lead to mobilization or freeze mode, instead, if there is increased vagal influence on the heart this would lead to prosocial behaviors (Porges, 2003). Looking at the neurological parts behind this, the myelinated vagus, which is linked to social communication, the sympathetic adrenal system which is linked to mobilization, and the unmyelinated vagus linked to immobilization. The three stages are built to respond to the environment, for instance, if it is perceived as safe, the myelinated vagus will activate and promote social communication, decrease the heart rate, and inhibit the other two mechanisms of fight or flight of the sympathetic nervous system. The production of cortisol also is decreased and as Porges suggested, the myelinated vagus really acts as

vagal brake, to calm the individual down (Porges, 1996). The systems are organized in a hierarchical way, so that the first system responds first (myelinated vagus), then if this fails to provide safety, the next one is activated and so on (Porges, 2007). Therefore, here we can see how the CVT, and which specific neural mechanisms are suggested to be behind ER and which consequence they have on the individual's behavior.

One of the ways to measure the CVT is through Heart Rate Variability (HRV). HRV is the time interval between each heartbeat (IBIs), and it indicates the ability of the heart to respond and adapt to internal and external stimuli (Laborde et al., 2017). HRV is generated by heart-brain interactions, between ANS processes and it is linked to many physiological processes, like blood pressure and gut and in general the regulation of the autonomic balance (Shaffer & Ginsberg, 2017). More specifically studies highlight that it is the interplay between neural mechanisms that input to the heart and sympathetic and parasympathetic vagal outputs of the Central Autonomic Network (CAN) which produce the beat-to-beat variability singular to each individual (Saul, 1990; Thayer & Lane, 2000). In the past HRV was only associated and measured to see if the heartbeat increased or decreased in response to a stimulus. Now, HRV is seen as an individual difference in addition to a response variable. This means that how the heart beats, how fast it responds to a stimulus, and then how quickly it takes to regulate, is also an individual characteristic (Laborde et al., 2017). Research shows that the resting HRV of an individual can be measured and analyzed, as a biomarker of psychopathology linked to comorbidity and other diseases (Beauchaine & Thayer, 2015).

HRV is a reliable non-invasive technique used to measure parasympathetic activity and therefore the vagal tone (Watanabe et al., 2023). To measure HRV

computers with algorithms are used to identify components of the ECG and measure the time interval between two heart beats (R-waves). However, it can also be complex to analyze, since there are three main domains of HRV to consider with various components; the frequency domain, the time domain, and the non-linear indices (Laborde et al., 2017). Each domain has different variables that can be analyzed based on the needs and the goals of the study to be conducted (Laborde et al., 2017). For instance, if the focus is the vagal tone, like for this paper, one is recommended to analyze the root mean square of successive differences (RMSSD), or the peak valley, or the high frequencies (HF) (Laborde et al., 2017). The RMSSD has in fact been shown to be highly useful when comparing and measuring at rest heart rate as individual characteristic (Thayer et al., 2009). At rest heart rate also called at rest CVT or tonic HRV, is when CVT as HRV is measured at one time point as baseline and when the individual is not exposed to a stressful stimulus (Laborde et al., 2017). At rest CVT has in fact been shown to work as protective factor in individuals since it is a well-grounded and effective technique that indicates the ability of autonomic regulation of the cardiovascular system (Sitovsky et al., 2020). It has been shown to be correlated to adaptability, resilience, self-regulation, and executive functions like attention (Laborde et al., 2017; Sitovsky et al., 2020).

Moreover, studies highlight the strong links between HRV as CVT and attentional control, affective disorders, and emotion (Porges, 1999; Shaffer & Ginsberg, 2017). Even though there is a mixed of findings, researchers show that high at rest CVT is related to higher self-regulation and ability to adapt, while low at rest CVT is associated to poor self-regulation and adaptability (Porges, 1992). Studies suggest that a reduction in HRV is linked to more symptoms of anxiety and depression disorders,

more importantly, ineffective emotion regulation and behavior inflexibility, which are essential for emotion regulation and adaptability (Thayer & Lane, 2000). Moreover, most research highlights how higher at rest vagal tone is associated with beneficial, positive aspects like better self-regulation, adaptability and resilience, better ability to cope successfully and efficiently with stressors and better executive functions like attention and emotional processing (Thayer et al., 2012; Thayer et al., 2009; Geisler et al., 2013; Shaffer & Ginsberg, 2017). In summary, even though, having a high HRV is not always the best options, for example in the elderly and for some pathologies, higher resting HRV has been associated to better health, adaptability, and resilience (Shaffer & Ginsberg, 2017). Literature also shows a difference in age and gender in HRV. There is a decline in age in HRV between 20 and 70, more specifically in RMSSD, assuming a U shape, with a decline mostly in the second and third decade of life, and then an increase again after the age of 70 (Bonnemeier et al., 2003). Regarding gender, women are found in general to have a higher mean HR with smaller R-R intervals and higher HF compared to men (Koenig & Thayer, 2016).

2.3 Emotion regulation in adolescents

It would be interesting to investigate if the same findings for ER and HRV can also be seen in adolescents. As already seen also in chapter 1, adolescence is a turmoil period of emotions, with rapid changes in moods and feelings. Moreover, an effective ER requires many skills like flexibility, awareness of one's emotions and of others, and responsiveness (Gross, 2013). All these skills firstly must come from external stimuli during childhood like the parents. For example, teaching children to label emotions, to recognise them, to talk about them and to reinforce their display. Instead during

development, with the increase in influence from social factors as well, the ER comes more from internal processes (Gross, 2013). Studies suggest that by adolescence one is able to cognitively regulate their emotions better and more, also based on the social context they are in and using more sophisticated strategies (Gross & Muñoz, 1995). Even though ER in adolescents still requires more attention, the research highlights the connection with other aspects of the self, in fact it has been linked to a self-system. More importantly, the self-esteem, studies show that high self-esteem is linked to positive adjustment, and lower internalizing and externalizing problems (Gross, 2013; Haney & Durlak, 1998). In addition, researchers suggest that during this development a number of emotion-based developmental tasks need to be achieved to reach the psychological and emotional maturity, which therefore makes emotion regulation essential for adolescents.

Moreover, many studies on emotion regulation on adolescents instead focus more on emotion dysregulation (Galambos & Costigan, 2003). Not being able to regulate appropriately can lead to affective dysregulation, which can have consequences like anxiety, depression (Thayer & Lane, 2000). This has been demonstrated in many studies, where they also showed how a bad emotion regulation in childhood can be the cause of problems in adulthood (Chapter 1). In addition, studies suggest that patterns of emotional functioning in childhood are maintained into adulthood, this means that a physiological response used to regulate during childhood/adolescence, if not regulated correctly during development can lead to maladaptive consequences (Sapolsky, 2007). Moreover, this shows how important it is to measure the children's and teenager's ability to regulate their emotions, because it can be an indicator for future health risk (Repetti et al., 2002). Gender differences in emotion regulation have also been noted.

For example, it is thought that females recur in more passive and ruminative coping styles, while males in more active and distractive strategies (Nolen-Hoeksema & Girgus, 1994). This also leads to developing more internalizing problems in females than boys during adolescence, like we have already seen (Wiklund et al., 2012; Yoon et al., 2023).

Regarding HRV, a variety of research on adolescents show that even though as mentioned before there is a variability by age, within adolescents, not much difference is noted, since the decrease starts later on (Reardon & Malik, 1996). As for adults, literature highlights how important it is to measure and analyse CVT at rest in children and adolescents for adaptability and self-regulation and how it acts as protective factor (Thayer et al., 2010). Moreover, research on CVT at rest (rmssd) in children and adolescents show that it can be used as an informative biomarker to measure and analyse psychopathological states (Sitovskyi et al., 2020). CVT at rest has been demonstrated to be very useful to predict the autonomic regulation, the ability to adapt and possible future problems like cardiovascular diseases (Sitovskyi et al., 2020; Vanderlei et al., 2012). As it was found in adults, higher at rest HRV has been shown to be related to better emotion regulation, psychophysiological health, and social functioning. Various studies show a lower HF HRV linked to depression and longitudinal studies show that a low HRV in adolescents can be used as biomarker for depressive symptoms in the future, especially anhedonia (Koenig et al., 2016; Dormal et al., 2021; Henje Blom et al., 2010; Vazquez et al., 2016). In addition, a significant difference is found between adolescents who sustain a healthy lifestyle like athletes, and who have a lower BMI and lower obesity. In fact, they are shown to have lower HR, possibly due to more cardiovascular activity and higher HRV (Routledge et al., 2010;

Sharma et al., 2015). Looking at differences by gender in adolescents, there is a mix of findings. Some show that boys have higher HRV, especially a difference is found in RMSSD, (Jarrin et al., 2015; Sitovsky et al., 2020), while others suggest the opposite (Galeev et al., 2002) or no difference (Goto et al., 1997; Bobkowski et al., 2017).

Chapter 3

Mindfulness

3.1 Defining Mindfulness: Trait vs state

As we have talked about mental health and emotion regulation, something that has been found to be closely linked to them is mindfulness. The term being mindful means being present in the moment, non-judgmental, free of any intrusive thoughts and focused on one-self's feelings and sensations (Kabat-Zinn, 2009). It comes from the Buddhist religion, and it is about "waking up" from the dreaming reality that one creates in their mind from emotions and thoughts, which then lead to specific actions. Being mindful means being in awareness of the now without thinking about the past nor the future.

Mindful meditation, in fact it is not some sort of sleeping or day dreaming, it is about taking time to be in touch with the inner self and listening to one's body and mind. This way will lead to clarity about one's perception of the self, one's actions and direction.

More specifically, mindful meditation teaches to use attention and awareness, which is something all humans have, in a healthy and productive way (Kabat-Zinn, 2009).

Mindfulness focuses on the unconscious, to change what has become automatic for our minds cognitively and behaviorally. Being aware in the moment has been shown to help break that "living on automatic-pilot mode" and to really appreciate and pay attention to our lives (Kabat-Zinn, 2009). Even though it was born as part of a spiritual practice, Kabat-Zinn has introduced mindfulness meditation to the western world for some time now, as a way improve mental and physical health (Kabat-Zinn, 2009).

Thanks to this, mindfulness has also been researched scientifically and more deeply explored. Literature showed that there are two different aspects that can be

investigated when studying mindfulness and its effects; one is mindfulness trait, this is something that an individual always has as part of themselves, of who they are, a way of being; it means having a better sense of self, more concentrated on the inner self and conscious in the moment, always. While on the other side there is the state of mindfulness, that it is not a characteristic that we always have, like part of our personality, it is a temporary state which can be induced for example through meditation and specific interventions (Goodman et al., 2017). For instance, in this paper the mindfulness trait will be investigated. The mindfulness trait is based on a predisposition to it, which remains stable over time (Brown & Ryan, 2003); however, some suggest that it is also something which can be trained and reinforced, for example, through mindfulness-based interventions (Kiken et al., 2015). More specifically, the Buddhist-based theories suggest that the more one practices the state of being deeply mindful during meditation, the more they will also show mindful attitudes in daily life, until it becomes a trait (Davidson, 2010). Literature on this topic is still mixed, with authors saying that state and trait are two separate things with little associations, while others suggesting a correlation. Nonetheless, neurobiological studies also highlight differences in neural processes between those with a mindfulness trait and those without. Those with a mindfulness trait show lower amygdala activation, and decreased connectivity in the middle regions (linked to mind-wandering), than those with no mindful trait (Creswell et al., 2007; Way et al., 2010). Moreover, an increased local synchronization in the occipital frontal cortex and in the inferior frontal gyrus was observed, which was associated to more positive emotions and a more sense of meaning and purpose in life (Kong et al., 2016). For this reason, mindfulness trait has also been linked to many positive outcomes in life and for the mental health, for example, lower

stress and rumination, better emotional intelligence and in general more positive emotions and less negative ones (Guendelman et al., 2017). Moreover, from a study including all mindfulness trait measures and with mental health questionnaires, it has been shown that the mindfulness trait is highly positively correlated with other variables like more openness, emotional intelligence, and self-compassion. While it is negatively correlated with psychological symptoms, neuroticism, thought suppression, and difficulties in emotion regulation (Baer et al., 2006). In general, mindfulness either as a state or as a trait has been demonstrated to bring many beneficial aspects emotionally and psychologically. For instance, mindfulness leads to less negative thoughts, and unhealthy behaviors and improves self-regulation and well-being (Kabat-Zinn, 2009). Moreover, studies show a reduction of stress and negative emotions and an increase in life satisfaction (Mandal et al., 2011; Guendelman et al., 2017). Mindfulness has also been used in treatments and has shown to also have a positive effect on psychological disorders like anxiety, depression and eating disorders (Shahar et al., 2010; Baer, 2003).

Even though many studies have been conducted, and many are still ongoing, it is not very clear how mindfulness in fact works, and no final theoretical framework has yet been proposed. As mentioned before, it is thought that there is a key interplay between attention and awareness, where meditating and being mindful increases our attention on the present and helps us turn it to what really matters, ourselves, without wasting it, and therefore amplifies our awareness (Kabat-Zinn, 2009). Other authors suggest that there are many mechanisms that contribute to mindfulness, and the ideas are mixed. Trying to include the main theories proposed, firstly, Shapiro et al. (2006) suggested that *attention, intention, and attitude* are the three main components, therefore intentionally paying attention with a non-judgmental attitude is the key to

mindfulness. Brown et al. (2007) instead believe that *insight, exposure, non-attachment, mind-body connection, and integrated functioning* are the main mechanisms.

Summarizing all of these, Baer et al. (2006) developed the Five Facet Mindfulness Questionnaire, built by analyzing other mindfulness scales, and suggested that mindfulness can be explained best by 5 facets: *observing, describing, acting with awareness, non-judging of inner experience and non-reactivity to inner experience*.

More recently, after a review of all the proposed theories, Hölzel et al. (2011) suggested that the main components of mindfulness are *attention regulation*, therefore focusing attention on one thing at a time and being able to turn attention back to it when distracted, *body awareness*, which means being able to focus on the inner self, for instance the body sensation, and the breathing. Then *emotion regulation* which means being able to approach emotional reactions in a non-judgmental way and with acceptance, and lastly *change in perspective of the self* which means detaching from a static sense of the self.

Moreover, research has also highlighted a very strong link between mindfulness and ER, like it has also already been mentioned. The first study investigating mindfulness and emotion regulation from a neurophysiological side, found that participants with higher mindfulness trait had higher prefrontal control over the amygdala and higher amygdala inhibition when confronted with labeling emotional face expressions (Creswell et al., 2007). This highlights the neurophysiological differences in individuals with higher mindfulness trait for emotion regulatory responses. Also, other studies conducted investigating mindfulness but as a state, showed that mindfulness practice leads to the activation of brain regions needed for emotion regulation with more practice leading to lower activation of the amygdala and more

inhibitory control (Hölzel et al., 2007; Farb et al., 2007). These mechanisms also explain the improvement found in many patients improving stress, anxiety, and depression (see Shahar et al., 2010) due to better emotion regulation. More specifically, authors suggest that mindfulness helps the interplay between top down and bottom-up emotion regulation mechanisms, through the pre-frontal cortex for attentional control (Guendelman et al., 2017; Lutz et al., 2014). Furthermore, studies show how mindfulness can lower emotion reactivity and improve emotion regulation and can also act as mediator to improve mental health, as we have also seen before (Guendelman et al., 2017; Mandal et al., 2012). In fact, some researchers suggested that mindfulness could be considered as an extra ER strategy based on a bottom-up system (Chambers et al., 2009; Chiesa et al., 2013). As discussed before one of the main mechanisms of mindfulness is attentional control/regulation, like for cognitive strategies in emotion regulation, like reappraisal (see chapter on emotion regulation). However, they work into two different manners, as reappraisal in the cognitive strategy it is about moving away the attention to the stimulus that provokes the emotions, while mindfulness wants to focus all the attention on the stimulus, until the bad emotions go away (Hölzel et al., 2011). Cognitive reappraisal in meditation becomes positive, trying to associate to the stimulus of bad thoughts and emotions to a good and positive aspect, like as constructive and meaningful (Garland et al., 2011). Modinos et al. (2010) in fact found that those with a mindfulness trait had more success in positive reappraisal and that they had higher activation in the brain regions needed for this emotion regulation. In summary, many studies have found the improvements in emotion regulation thanks to mindfulness and the close connections between the two.

Lastly, the beneficial effects of mindfulness in emotion regulation can also be measured by physiological responses. For example, studies have been conducted showing that meditation leads to decrease in heart rate, decrease in cortisol levels, blood pressure, and skin connectivity and decrease in respiratory heart rate (Zeidan et al., 2010; de la Fuente et al., 2010; Carlson et al., 2007; Lazar et al., 2005). This is because during mindfulness meditation the parasympathetic activity is increased while the sympathetic activity decreased (Hölzel et al., 2011). As we have seen before for the CVT, during parasympathetic activation the vagus nerve activates and if the environment is perceived as safe, myelinated pathways are activated and this brings more prosocial behavior, slower heart rate and more positive emotions and outcomes (see paragraph on CVT). However, since as discussed before one of the key to mindfulness is the association of positive aspects to the negative stimulus, even when faced with a stressful stimulus during mindfulness, the environment is still be perceived as safe and therefore this process activated. This is why mindfulness has been shown to be correlated to higher HRV and CVT. In two recent literature reviews including more than 10 years of papers, it was highlighted how mindfulness practice was associated to increases in HRV and more specifically in the measures RMSDD, SDNN and HF associated to the activation of the parasympathetic system and well-being. HRV has in fact been suggested to be an objective biomarker for mindfulness interventions (Tung & Hsieh, 2019; Christodoulou et al., 2020).

3.2 Mindfulness in Adolescents

In children, preadolescents, and adolescents many studies have been conducted as well, showing the effects of mindfulness. As it was also shown for adults, mindfulness in adolescents can be researched and measured either as a state or as a trait. Studies

focusing on mindfulness interventions show a decrease in rumination and stress comparing pre- and post-intervention (Shapiro et al., 2008). Moreover, a variety of researchers highlight the beneficial effects of mindfulness-based programs implemented in schools (Schonert-Reichl, 2015; Amundsen et al., 2020; Meyer & Eklund, 2020). Mindfulness has also been shown very effective for psychological disorders in teenagers such as eating disorders and anxiety (Salbach-Andrae et al., 2008; Semple et al., 2005). However, looking more at the studies conducted investigating the mindfulness trait in pre- and adolescents, studies show that those with more mindfulness trait, also demonstrate fewer depressive symptoms, less stress, and less anger (Black et al., 2012b; Brown et al., 2011). Cunha et al. (2013) conducted a study on Portuguese adolescents and found that those who scored higher on the mindfulness trait scale Child and Adolescent Mindfulness Measure (CAMM) also showed higher school achievement mediated by better executive functions. Another study which used the same scale on Dutch adolescents found that more mindfulness trait from the CAMM was strongly correlated with more happiness, healthy self-regulation, and better quality of life; instead, they were strongly negatively correlated with stress, rumination, self-blame, and catastrophizing (de Bruin et al., 2014). Very similar findings were also proposed by Greco et al. (2011) who found that higher mindfulness trait was associated with better quality of life, academic competence, and social skills, while negatively correlated with somatic complaints, internalizing symptoms, and behavioral problems.

If mindfulness trait has also gender differences in pre-adolescents is something to be explored. Previous research is mixed, Ristallo et al. (2016) and Thirumaran et al. (2020) proposed how girls show a more mindfulness trait than boys, while Greco et al. (2011) and Cunha et al. (2013) found no difference.

As the previously mentioned studies suggest there is an association between mindfulness trait and emotion regulation, showing that more mindfulness trait in pre-adolescence, like in adults, has been linked to better emotional intelligence and self-regulation (de Bruin et al., 2014; Miao et al., 2018). Focusing on CVT, from a meta-analysis by Van Loon et al. (2022), it was shown that many studies in adolescents highlight the positive physiological effects of mindfulness interventions, with HRV considered as a useful measure of emotion regulation. However, very few investigate HRV specifically, and the few present studies do not show a significant change between pre and post mindfulness intervention (Ivaki et al., 2021; Robe & Dobrea, 2023; Zitron & Gao, 2017). Moreover, even less studies have been conducted on mindfulness trait on pre-adolescents and adolescents linking mindfulness trait with HRV and mental health, and this is also why this study focuses on it.

The present study will therefore attempt to address this existing gap in literature and expand on previous studies investigating the possible correlations between mindfulness, mental health and CVT in pre-adolescents/adolescents.

Chapter 4

Methods

4.1 Current Study

The overall aim of the present study was to assess the relationship between emotion regulation as indexed by cardiac vagal tone at rest, mindfulness, and mental health in pre-adolescents.

More specifically four research questions guided this study:

- 1) How and how much pre-adolescents are able to mindfully focus on their bodily sensations?

Here, based on the previously reported literature, we expect that pre-adolescents will be able to pay attention to their bodily sensations as suggested by the many studies conducted on mindfulness using self-report scales (Black et al., 2012b; Brown et al., 2011; Cunha et al., 2013).

- 2) Is there an association between emotion regulation as indexed by cardiac vagal tone at rest and mental health and mindfulness?

Here, based on the previously reported literature, we expect there to be an association between CVT, mental health and mindfulness. More specifically we hypothesize that better mental health will be positively correlated with CVT at rest (rmssd), and so better emotion regulation (Porges, 1992; Thayer et al., 2009; Thayer et al., 2012; Geisler et al., 2013; Shaffer & Ginsberg, 2017) and that mindfulness trait will be associated with better mental health (Greco et al., 2011; de Bruin et al., 2014; Black et al., 2012b; Brown et al., 2011; Cunha et al., 2013). We also expect that mindfulness trait will be positively correlated with CVT at rest, as an exploratory hypothesis since no previous studies have been conducted on this.

- 3) Do the main variables differ across gender?

Based on the literature (Yoon et al., 2023) we expect there to be a difference by gender for mental health, with girls having higher emotional problems than boys. In addition, since literature is mixed on mindfulness trait and at rest CVT, based on the previous hypothesis, we expect higher mindfulness trait in boys (Greco et al., 2011; Cunha et al., 2013) and higher CVT at rest in boys (Jarrin et al., 2015).

- 4) Is pre-adolescent's mental health directly or interactively influenced by cardiac vagal tone, mindfulness, and gender?

This is an explorative hypothesis since no previous literature has focused on this, we expect mental health to be influenced directly by CVT, gender and mindfulness, but also a supposed interaction is hypothesized with an interplay between the variables leading to better or worst mental health.

4.2 Participants

A total of 149 (F=87, M= 62, Mage= 11.56, SD=1.32, range=10-13) sixth and seventh graders were involved in the study conducted in a middle school in Padova. The study was conducted including 11 classes and the experiment was done only with pre-adolescents that brought back the consent form signed by their parents/legal guardians in time.

4.3 Procedure

Data collection was done from October 2023 to February 2024. Written informed consent was obtained by parents or legal guardians of all participating students. There was an initial session done in each class where the researchers introduced themselves and explained what was going to happen in the following sessions through a small PowerPoint presentation. Subsequently, a few days after, in accordance with availability from the school and professors, the SDQ questionnaires and the CAMM questionnaire were administered in each class. Each student was given a code and the questionnaires were all accessible through a specific platform with the students' tablets. The students were guided on how to get to the questionnaires and were assisted if needed help with anything. At the end of the questionnaires, when everyone finished, the mindfulness exercise was conducted. Students were asked to pay attention for 1 or 2 minutes while

the exercise was demonstrated. The demonstration was done as follows: one hand was on the chest and one on the tummy and students were asked to focus on their breath for 1 minute and to do it slowly. If they wanted they could close their eyes to concentrate better. The same phrases to explain the exercise were always used so that no confusion could be made (Appendix 1). The first cycle of breath guided was done and then students were left to do 4 by themselves in their own time. Once this was done, the papers previously prepared with the open question asking what they felt during that exercise were handed out. A drawing of a human body was also added to the question to favor and simplify their understanding of what was asked of them and to help them in case they preferred indicating exactly what they felt on their body (Appendix 2). Once this was done, the papers were collected, and the next classes were administered. The final session of the experiment was to measure the students' CVT. This was done calling out one student at a time and bringing them in another classroom. The class was empty and had been previously set up with all the materials needed: the laptop with the software to show the ECG and the codifying system to measure HRV. In addition, a laptop was set up for the student to look at, while seated on a chair positioned only looking at the screen and with minimized distractions. This was also done in a way to see each movement of the student, but while seating behind or next to him. Students were asked to put on the H10 polar strap around their waist to measure their heart rate and were asked if and what they ate before, if they did any physical activity, for example if they had P.E. class before and (for females) if they had already had their period. They were then asked to sit as still as they could, to do not cross their legs or arms and to do not talk. A neutral calming video documentary of birds was put on, 8 minutes long to measure the resting HRV of the student. Always the same video and

same location was used for each student. While the video was on, there was no distraction of sounds or movement in the classroom, only the experimenter at the laptop pressed the keys to start and finish the recording sessions. In addition, the experimenter wrote down if and at what minute of the recording the student moved or laughed or talked for example, or if any interruption occurred for any reason. Once the video was over the HRV recording session was stopped, the polar strap was taken off and the student was sent back to their class.

4.4 Measures

Mindfulness

To measure mindfulness two measures were used. Firstly, the Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011) questionnaire. This is a well-known and standardized measure which allowed us to collect quantitative results. It is composed of a scale with 10 items measuring the present moment awareness, in a 5-point Likert scale (0-*never true* to 5-*always true*). Secondly, a more qualitative, not standardized measure was used to understand better the mindful trait of each student from a more subjective perspective. We built a mindful exercise focused on the breathing, 2 minutes long, and then administered an open question asking how they felt during the exercise (Appendix 2). More precisely, we wanted to measure the number of emotional states they mentioned they felt during this exercise and the amount of physical sensations they managed to pay attention to and report.

Mental Health

To measure mental health, the Strengths and Difficulties Questionnaire (SDQ; Goodman et al., 1998) was used. The adolescent version was used, for self-completion and for ages 11-17. The questionnaire is composed the same but worded differently. It is composed of 5 subscales (emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, prosocial behavior) including 25 psychological traits, positive and negative.

Cardiac Vagal Tone- HRV Physiological Measure

To investigate the cardiac vagal tone a strap with the polar H10 attached was positioned around the torso of the child so that the sensor would be in contact with the skin of the child (Figure 1). The sensor codifies the cardiac tone in real time transmitting it to a dedicated computer (ProComp Infiniti, Thought Technology; Montreal, Canada) through a multimodal monitoring system. The ECG signal is processed at 12-bit from analog to digital and converted with a sampling rate of 256 volts per second. Subsequently, the intervals between each heartbeat are calculated, which is the difference in milliseconds between the R waves, using the software Kubios-HRV Analysis 2.2 (The Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Finland). Furthermore, the mean frequencies of the at rest heart rate (HR) and the squared roots of the differences between the intervals (rMSSD) were calculated. These represent an index sensitive to the measurements of the cardiac vagal tone since they directly reflect the parasympathetic activity carried out by the vagal nerve. To do this a computer codifying system was used, the FlexComp Infiniti™

(Thought Technology Ltd, Montreal, Canada), approved by the “U.S. Food and Drug Administration” (FDA).



Figure 1: Representation of the Polar H10 strap and of its positioning.

Source: <https://www.polar.com/it/sensors/h10-heart-rate-sensor/>

Source: https://support.polar.com/it/support/wearing_the_heart_rate_sensor

4.5 Data analysis

Data were first observed by running a series of descriptive statistics for each study variable.

Subsequently the following specific analyses were performed to answer the four research questions.

- 1) Descriptive statistics were performed to observe how and how much pre-adolescents are able to mindfully focus on their bodily sensations and correlations were performed to assess if the mindfulness scale is associated with the number of sensations and emotional states adolescents perceive.
- 2) In order to assess if there is an association between emotion regulation as indexed by cardiac vagal tone at rest and mental health and mindfulness a number of correlations were performed.

- 3) In order to assess if all variables differed across genders a set of ANOVA were performed while controlling for age.
- 5) In order to assess if pre-adolescents' mental health is directly or interactively influenced by cardiac vagal tone and mindfulness a regression analysis was performed including age and gender as covariates.

Chapter 5

Results

5.1 Mindfulness

Descriptive statistics were performed to observe how and how much pre-adolescents are able to mindfully focus on their body. All youths' answers were grouped into different categories that were either related to emotional physical sensations. In addition, the frequency of the labels they used to describe sensations and emotional states during the two minutes of mindfulness in the classroom was registered. Data are reported in Table 1 where each emotional and physical label is also described through an example. Frequency of use are also reported in Figure 2.

Emotional states and physical sensations	Category	Number of times used	Example of used phrases
Rilassato	Physical sensation	34	<ul style="list-style-type: none"> - “Le mie mani e gambe erano rilassate” - “Testa e muscoli erano rilassati” - “Punte dei piedi rilassate” - “Rilassamento schiena” - “No forze in tutto il corpo” - “Immobile” - “Paralizzato” - “Muscoli come quando ti stiri”
Respirazione	Physical sensation	30	<ul style="list-style-type: none"> - “Quando respiravo mi facevano male i polmoni e quando buttavo fuori l’aria mi sentivo più leggero” - “Mi sono riuscito a concentrare sul mio respiro e sul mio corpo” - “Sentivo il rumore del respiro” - “Sentivo l’aria che entrava nei polmoni” - “Mi sono sentito come in un bosco con aria fredda e pulita nei polmoni” - “Sentivo la pancia che si muoveva e si gonfiava” - “Leggera pressione al petto e naso chiuso” - “Quando inspiro le gambe si alzano e mi sento la schiena dritta” - “I polmoni aperti”

Male alla testa	Physical sensation	11	<ul style="list-style-type: none"> - “Ho avuto mal di testa” - “Mi sono sentita girare la testa” - “Mi sono sentita un peso sulla testa”
Male alle gambe	Physical sensation	5	<p>“Intrappolato, male ai gomiti e alle gambe”, “gambe rigide”, “male alle gambe e ai piedi.”</p>
Battiti del cuore	Physical sensation	20	<ul style="list-style-type: none"> - “Cuore rilassato” - “Mi sono concentrato sul battito del cuore” - “Sentivo il cuore che batteva forte” - “Ho sentito l’aumento dei battiti del cuore”
Concentrata nei pensieri	Physical sensation	22	<ul style="list-style-type: none"> - “Concentrata nei pensieri” - “Concentrato nella testa” - “Testa rilassata” - “Tranquillità nella testa” - “Sentivo la testa vuota” - “La testa a lavoro ma calma” - “Mi sembrava di essere da sola in classe” - “Ho sentito il silenzio” - “Pensiero vuoto” - “Testa accesa” - “Pensieri nel cervello”
Sonnolenza	Physical sensation	11	<ul style="list-style-type: none"> - “Sonnolenza” - “Stavo per dormire”
Male alla pancia	Physical sensation	7	<ul style="list-style-type: none"> - “Pancia agitate” - “Male di pancia” - “Dolore alla pancia”

Occhi chiusi	Physical sensation	6	<ul style="list-style-type: none"> - “Sensazione di occhi chiusi” - “Ho sentito gli occhi chiusi” - “Ho chiuso gli occhi” “Occhi un po’ male”
Formicolio	Physical sensation	8	<ul style="list-style-type: none"> - “Sentivo un formicolio alle mani” - “Sentivo un freddo formicolio” - “Formicolio sulle braccia” - “Vibrazione sulle mani”
Male alle braccia/spalle	Physical sensation	4	<ul style="list-style-type: none"> - “Male ai gomiti” - “Male alle braccia” - “Un peso sulle spalle” - “Spalle rigide” - “Fastidio alle spalle”
Libertà	Emotional state	12	<ul style="list-style-type: none"> - “Una sensazione di libertà” - “L’aria nei polmoni ti fa sentire libero, e ti fa rilassare come stare sulle nuvole e libero” - “Libera, Libera di pensare” - “Mi sono sentita come una farfalla che vola nel cielo azzurro” - “Mi sentivo sopra a una nuvola” - “Come se non avevo più pensieri” - “Leggero”

Benessere	Emotional state	18	<ul style="list-style-type: none"> - “Sensazione di benessere e pace” - “Mi sento bene” - “Bene come in paradiso” - “Bene” - “In sintonia con il mio corpo” - È stata una sensazione piacevole” - “Piena di energia”
Felicità	Emotional state	10	<ul style="list-style-type: none"> - “Mi sono sentito felice” - “Una sensazione di gioia” - “Ho sentito gioia dentro di me”
Rilassato	Emotional state	31	<ul style="list-style-type: none"> - “Rilassata/o” - “Rilassata non ho pensato a nulla” - “Mi sono sentita molto rilassata”
Disagio	Emotional state	10	<ul style="list-style-type: none"> - “Come una lunga corsa” - “Come dopo che hai fatto sport” - “Imbarazzata perché non avevo mai fatto questa cosa” - “Disagio” - “Ansiosa” - “Soffocato” - “Una sensazione di vuoto”

Tranquillità	Emotional state	29	<ul style="list-style-type: none">- “Mi sono sentita tranquilla senza preoccupazioni”- “Sensazione di tranquillità”- “Serenità, sciolta e tranquillità”- “Tranquillità nella testa”- “Tranquilla”- “Mi sono sentita tranquilla come se non avevo più pensieri”- “A lavoro ma calmo”
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Table 1. *Qualitative analysis results of the mindfulness exercise. The mostly mentioned emotional states and physical sensations are reported and analyzed.*

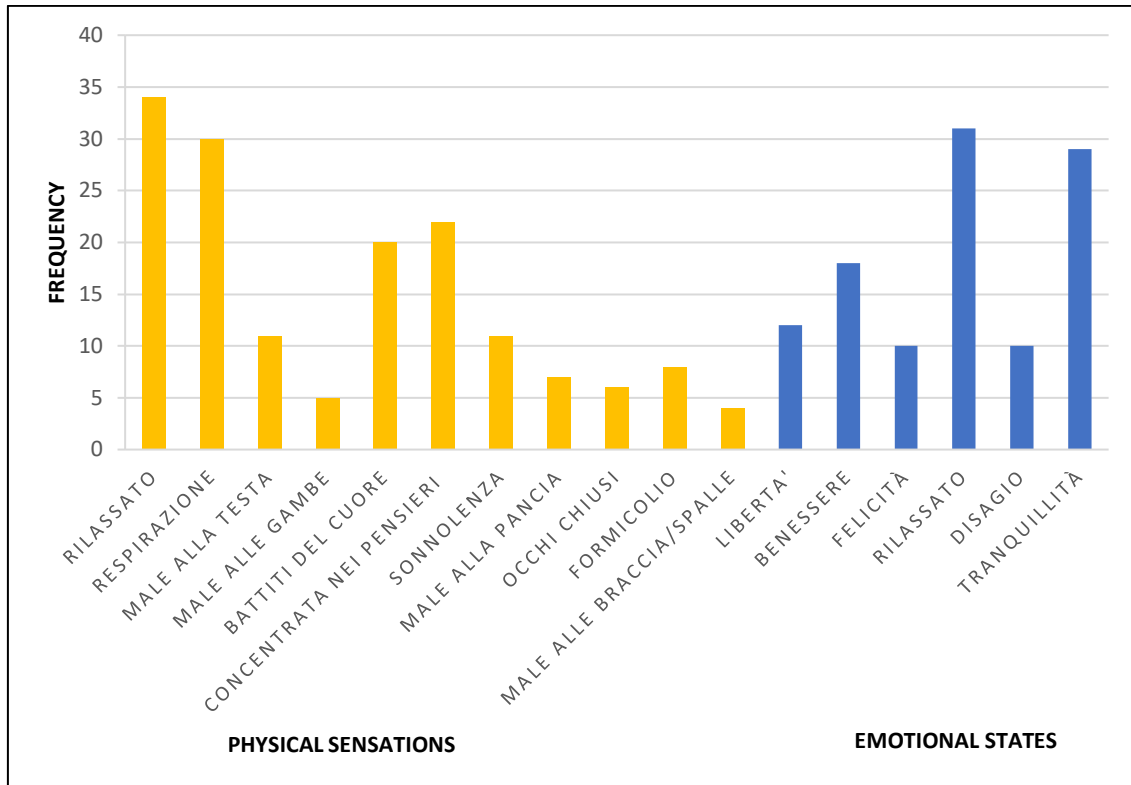


Figure 2. Qualitative analysis results of the most popular physical sensations and emotional states mentioned by the participants after the mindfulness exercise. On the x-axis in yellow the physical sensations, and in blue the emotional states. On the y-axis the frequency with which each sensation has been mentioned.

Correlations were performed to assess if the number of sensations and emotional states detected during the 2 minutes of mindful practice were correlated with the mindfulness questionnaire. As shown in figure 3 while the number of sensations and emotional states were highly negatively correlated there was no significant correlation with the mindfulness scale and the number of sensations or states. As shown in Figure 3 the mindfulness questionnaire was normally distributed, while a right-skewness is present for feelings and sensations.

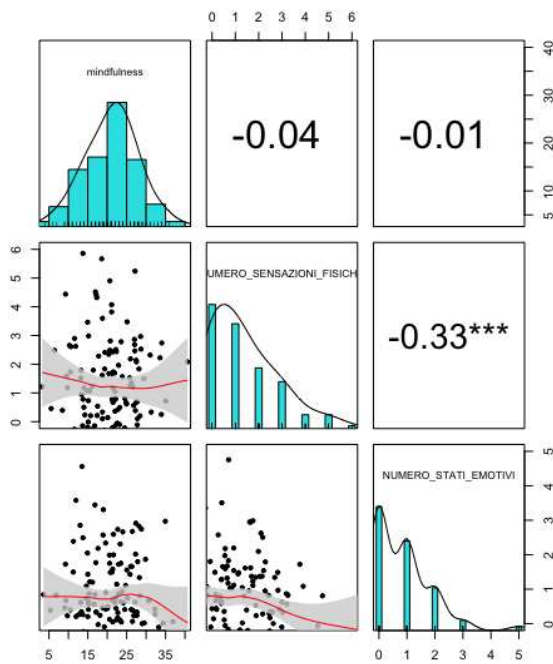


Figure 3. Correlations between the mindfulness questionnaire, and the mindfulness exercise results with emotional states and physical sensations.

5.2 Mindfulness, cardiac vagal tone, and mental health

In order to assess if there was an association between emotion regulation as indexed by cardiac vagal tone at rest, mental health and mindfulness, a number of correlations were performed. As shown in figure 4, cardiac vagal tone is negatively correlated with emotional problems but is not associated with mindfulness. Mindfulness however is strongly negatively associated with emotional problems. The distributions of RMSSD is rightly skewed while a right-skewedness is present for emotional problems.

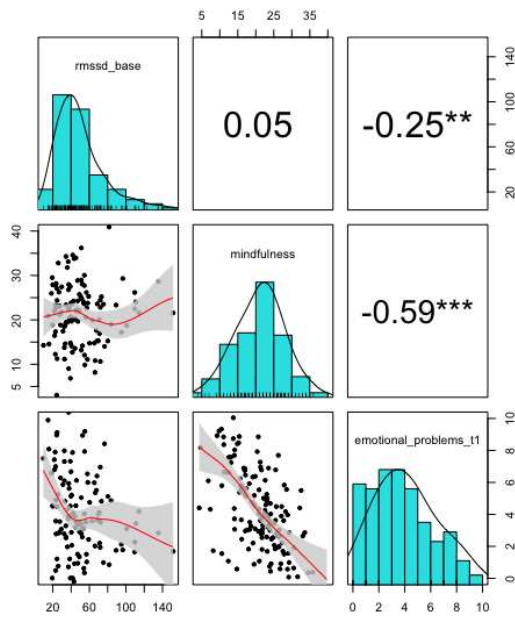


Figure 4. Correlations between the cardiac vagal tone at rest measurements, mindfulness, and the reported emotional problems.

5.3 Gender Differences in Mindfulness, Cardiac Vagal Tone and Mental Health

To assess if the studied variables differed across gender a number of analyses of variance were performed while controlling for age. As reported in table 2 a significant gender difference was found in cardiac vagal tone and emotional problems but not in the mindfulness scale.

	Male	Female	Group comparison
	<i>M(SD)</i>	<i>M(SD)</i>	
Cardiac vagal tone	57.76 (26.89)	43.53 (22.74)	$F(1,117) = 9.71, p = 0.002$
Mindfulness	22.33 (6.69)	20.34 (6.52)	$F(1,146) = 3.37, p = 0.06$
Mental health	3.17 (1.98)	4.81 (2.47)	$F(1,146) = 18.47, p < 0.001$

Table 2. Gender differences between the variables: mindfulness, mental health, and cardiac vagal tone.

5.4 Mental Health: The Role of Mindfulness Cardiac Vagal Tone and Gender

In order to assess if pre-adolescent mental health is directly or interactively influenced by cardiac vagal tone, mindfulness and gender a regression analysis was performed including age as covariates. As shown in table 3 a significant interaction is seen in the three-way interaction between CVT, mindfulness and gender ($p < 0.05$).

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
Cardiac vagal tone	0.14	0.09	1.46	0.14
Mindfulness	0.15	0.24	0.62	0.53
gender	8.05	3.28	2.45	0.01*
age	-1.64	5.90	-0.27	0.78
CVT*mindfulness	-0.006	0.004	-1.47	0.14
CVT*gender	-0.13	0.05	-2.31	0.02*
Mindfulness*gender	-0.28	0.14	-2.02	0.04*
CVT*mindfulness*gender	0.005	0.002	2.171	0.03*
R²	.47			

Table 3. *Linear regression*

To better explore the three-way interaction, we plotted the slopes of mindfulness by different degree of cardiac vagal tone and gender. As shown in Figure 5 among boys there is no effect of higher or lower CVT (rmsd base) on emotional problems, which changes only as a function of mindfulness, that is greater mindfulness is associated with less emotional problems (negative correlation). Yet among girls, also CVT plays a role. That is girls with lower CVT highly benefit from greater mindfulness as this is linked with lower emotional problems (negative correlation). The same is not true for high CVT girls that always report lower emotional problems independently of their

mindfulness level. Overall, comparing the two graphs, emotional problems are lower in boys than in girls, supporting previous findings. Regarding mindfulness, we can see that the more mindfulness trait, the less emotional problems he/she has, and this is true for both boys and girls, as previously reported.

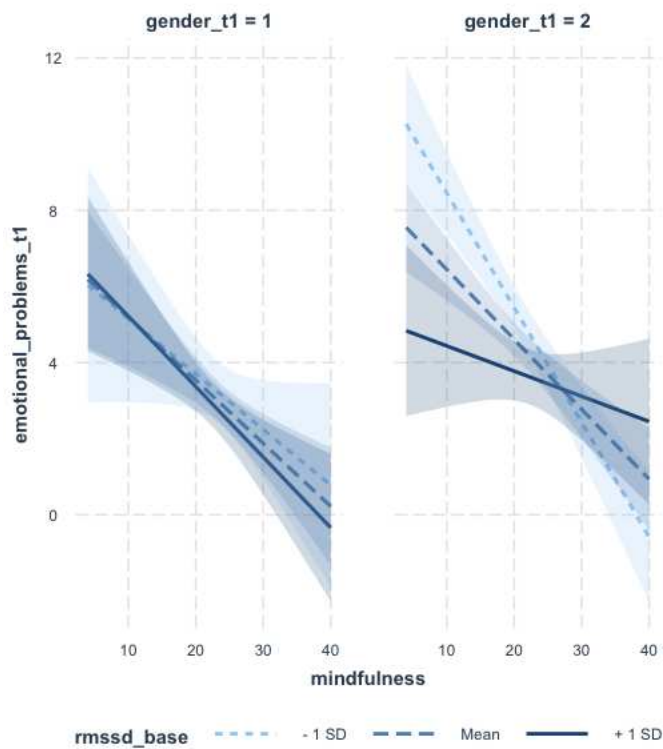


Figure 5. *The graph shows the three-way interaction between gender, mindfulness and CVT.*

Chapter 6:

Discussion

The first aim of this research was to understand if pre-adolescents would be able (and to what extent) to understand and report their physical sensations and emotional states. It was hypothesized that pre-adolescents would be able to focus on and understand their feelings, considering all the previous literature done on children and adolescents using self-report measures (Black et al., 2012b; Brown et al., 2011; Cunha et al., 2013). From the results, all students completed the CAMM questionnaire successfully, however, the descriptive analysis from the mindfulness exercise showed that students were not always able to clearly distinguish emotions from sensations and the descriptions were mostly vague and not detailed. From this, it would suggest that pre-adolescents do not actually have a very good awareness of feelings and sensations. Moreover, looking at further analysis, no correlation was found between the mindfulness questionnaire and the qualitative exercise, highlighting the discrepancy between two different measures that were supposed to assess similar aspects of being mindful. This did not show consistency in our results. Our exploratory hypothesis was therefore not supported, but more interestingly than this, let us explore why it could be that the two measures did not significantly correlate. Many factors come into play, Goodman et al. (2017) suggested how some scales used to assess mindfulness trait do not correlate with each other, which could be because they focus on different facets of mindfulness, but also because of the different interpretations one can give to the questions. Therefore, considering the first possibility, it could be that the CAMM and the mindfulness exercise were measuring different aspects of mindfulness. The CAMM has been shown to have a unidimensional

focus on mindfulness (Bender et al., 2023) assessing the main aspects of acting with awareness and accepting without judgement (Kuby et al., 2015); while the open-ended question had instead a focus more on feelings and sensations awareness. Therefore, it could be that this was why no correlation was found between the different measures. However, some literature also suggests how non-judgmental behavior is positively correlated with more self-awareness of thoughts and emotions, in contrary to what was found in the present study (Saggino et al., 2017). In previous research, it is yet not clear which facets and scales are the most descriptive and suited to measure mindfulness trait, especially in children, since scales have been developed fairly recently (Greco et al., 2011). In addition, research suggests how hard it is to find common ground and reach a conclusion, since different definitions of mindfulness keep being used with results that assess different constructs (Bender et al., 2023). In fact, as it was explored in Chapter 3 of this paper, mindfulness does not yet have a clear and widely accepted theoretical framework, however, a recent meta-analysis proposes how awareness, non-judgmental acceptance and present-moment attention are the main aspects that need to be researched (Bender et al., 2023), which are also in line with Kabat-Zinn's definition of mindfulness which is widely used. Considering this final literature, the CAMM would seem to be a more indicative measure of mindfulness than the open question. However, going back to the second possibility for no correlation proposed by Goodman et al. (2017) given by different interpretations, the CAMM includes negative worded items or with negative descriptors; this has been shown that could lead to misunderstandings of the items and confusion in children and adolescents (Cortazar et al., 2020; Bender et al., 2023). Moreover, it has been found that children and adolescents tend to respond higher

to positively worded questions than negative ones, therefore could have affected our results (Cortazar et al., 2020).

The second aim was to investigate if there was an association between emotion regulation measured as CVT at rest, mindfulness trait and mental health. It was hypothesized that there would be a relationship, more specifically that mental health would be positively correlated with CVT at rest, thus indicating that better abilities to self-regulate should be linked with better mental health (Makovac et al., 2022; Henje Blom et al., 2010; Vazquez et al., 2016). Similarly, we expected a positive relationship between mindfulness trait and better mental health (Greco et al., 2011; de Bruin et al., 2014; Black et al., 2012b; Brown et al., 2011; Cunha et al., 2013). We also expected that mindfulness trait would be positively associated with CVT at rest, as an explorative hypothesis. From our results an association was found between mental health (emotional problems) and CVT at rest (emotion regulation), with a negative correlation between the number of emotional problems reported by the students and CVT at rest. This is in line with the theories suggested by Porges (1992) and Thayer et al. (2009) and several studies conducted on adults, adolescents, and children where CVT worked as a protective factor (Makovac et al., 2022; Thayer et al., 2012; Thayer et al., 2009; Geisler et al., 2013; Shaffer & Ginsberg, 2017). Mindfulness trait was found to be strongly negatively correlated with emotional problems, supporting our hypothesis that mindfulness trait is correlated with better mental health and in line with the theory by Kabat-Zinn (2009) and previous research (Greco et al., 2011; de Bruin et al., 2014; Black et al., 2012b; Brown et al., 2011; Cunha et al., 2013). Interestingly CVT at rest was not found to be significantly correlated with mindfulness trait, to our knowledge this is the first study investigating this relationship. The lack of correlation between the

two seem to underline that they are measuring two different things: on one side the ability to self-regulate and better adapt to the environmental requests (CVT, Porges, 2007), and on the other side the ability to be present in the moment, non-judgmental and aware of one self (mindfulness trait, Bender et al., 2023).

The third aim investigated if the variables mindfulness trait, mental health and CVT at rest changed based on gender. It was expected that there would be a difference by gender for mental health, with girls having higher emotional problems than boys. In addition, we expected there to be a difference in gender also in CVT and mindfulness, but since literature is mixed, based on the previous hypothesis, we expected higher mindfulness trait in boys and higher CVT at rest also in boys. Results showed that a significant gender difference was found in CVT and mental health but not in mindfulness trait. More specifically, higher CVT in boys was found, supporting the hypothesis and one side of the existing literature (Jarrin et al., 2015). Higher emotional problems, therefore worst mental health in girls compared to boys, supporting our hypothesis and previous literature (Yoon et al., 2023). No mindfulness trait difference was found between males and females, supporting previous literature (Cunha et al., 2013; Greco et al., 2011), but not the research hypothesis.

The fourth and last aim of this study was to understand better if mental health was influenced directly or interactively by mindfulness trait, gender, and emotion regulation (CVT). It was hypothesised that mental health would be influenced directly by CVT at rest, gender, and mindfulness trait, like investigated in the previous research questions, but also an interaction was hypothesized between the variables leading to better or worst mental health. Interestingly, a three-way interaction between CVT at rest, mindfulness and gender was found significant. The interaction showed a different

pattern for boys and girls with no effect of CVT among males, and emotional problems only changing as a function of mindfulness trait: greater mindfulness, less emotional problems. Among females, having a greater CVT was a protective factor, as independently from mindfulness levels girls with higher CVT reported less emotional problems, yet among girls with low CVT having high levels of mindfulness decreased the levels of emotional problems (working as a protective factor like in boys).

The study is not free from limitations. For instance, self-report measures both quantitative with the CAMM questionnaire, and qualitative with the descriptive open question, were used to measure mindfulness. While this is a good way of measuring mindfulness since it is an internal process, using self-report measures is always risky, since they could bring many confounding variables which cannot be controlled for. Many studies have highlighted the self-report bias in self-perception and how this can make self-reports less reliable (Baumeister et al., 2007; Grossman, 2011). For instance, in the present study it could be that students were hiding or lying reporting what they really felt. Moreover, since both the questionnaire and the exercise with the open question were done in class, it could be that some copied what was written by the peer next to them. In addition, the expectation error could have come into play, since it could be that if some students had done something similar before they knew what was expected of them and therefore wrote what they thought was going to be “right”. Another reason could be that they did not pay attention to the experiment while being distracted by peers or other things in class and therefore did not take the right time to feel and write down their sensations. This could have affected our findings for the first research question on mindfulness and adolescents’ awareness. Something else which some papers suggest can influence mental health, CVT and mindfulness trait are culture,

religion, and nationality (Goodman et al., 2017). These are variables which we did not ask or control for.

Nevertheless, this paper also has strengths. Even though the CAMM is indeed a self-report measure, it has been widely used in research to measure trait mindfulness in children and adolescents. It has been translated into many languages to be used in many countries and it has been tested and analyzed on Italian children and adolescents and it has been shown to have good psychometric properties and good internal consistency and concurrent validity (Saggino et al., 2017; Meyer & Eklund, 2020; Bender et al., 2023). It has been proposed to be a good measure of mindfulness trait in children and has been validated for children of ages 10-17 (Greco et al., 2011; Bender et al., 2023). Another strength of the CAMM is that it has been shown to not be affected by meditation or yoga practice in children (Goodman et al., 2017). Moreover, to increase the construct validity of the CAMM, studies show that it has a positive correlation with other mindfulness trait scales (de Bruin et al., 2014). Furthermore, in the present study two different measures were used to investigate mindfulness trait, one quantitative standardized measure (the questionnaire) and a qualitative, more subjective one (the open-ended question). Previous research has proposed to use other strategies to measure mindfulness trait other than the self-report questionnaires, like behavioral observation or using vignettes with open-ended questions for their thoughts (Bender et al., 2023), but this is the first time in research that it was out into practice and tested and this is one of the reasons why this study can contribute to existing literature. In addition, the open-ended question and the exercise were worded so that they could not prompt in any way the responses of the students and be completely neutral (see Appendices). Moreover, this paper fills a gap in literature by focusing on pre-adolescents, and measuring their

mindfulness trait, CVT, mental health, and their relationships, all in one study, and no previous literature has done it. Another strength of this study is the use of a physiological measure to analyse emotion regulation. As proposed in the introduction there are many studies that link emotion regulation and CVT and therefore HRV as a valid measurement of it. Moreover, many studies show how reliable this measurement is and that is a good biomarker of emotion regulation also in children (Beauchaine & Thayer, 2015). Previous literature often uses self-report questionnaires or stress measurements which are less valid and less reliable because of all the confounding variables (Kim et al., 2018). Therefore, being able to use a physiological and objective measure to investigate something as broad and subjective as emotion regulation, adds strength to this study and to its results.

Something interesting that could be explored for further research is if mindfulness trait is in fact something which can be trained, as some studies suggest (Bishop et al., 2004) or if some demographics or some individual factors affect the mindfulness trait of a person. For example, those that have specific characteristics, religion, culture, or practice a particular sport, and then replicate this study controlling for those factors and see if they affect the results. In addition, considering the existing literature on the effects of culture, religion, and nationality on mental health, CVT and mindfulness (Goodman et al., 2017), it would be fascinating to see if the same study but conducted in other countries would replicate the same findings. Moreover, since the findings found on the CAMM showed how negative worded items could have affected the results, it would be interesting to replicate the study but with the revised version of the CAMM (CAMM-R, Mezo et al., 2020). Lastly, as this study is one of the only ones producing findings on pre-adolescents, mindfulness and CVT, and since like it has been

previously said, this study adds many new things to the literature, like the mindfulness exercise, the qualitative measure of mindfulness trait, and the physiological measure of emotion regulation, it would be interesting to replicate the study.

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Appendices

Appendix A: instructions given before the mindfulness exercise.

Ora eseguiremo un esercizio di mindfulness. Mindful significa essere presenti e consapevoli nel momento che si sta vivendo non solo con il proprio corpo ma anche con la mente e le proprie emozioni. Durante questo esercizio ci servirà il vostro più assoluto silenzio e concentrazione. Durerà solo un minuto, ma vi chiediamo di prestare molta attenzione alle istruzioni perché dopo ci saranno delle domande. Durante questo minuto vi chiediamo di chiudere gli occhi e sedervi appoggiando la schiena alla sedia e rilassandovi il più che potete. Ora vi mostreremo come eseguire una respirazione profonda e controllata per rilassarvi ancora di più. Per fare questo dovete concentrarvi sul vostro respiro. Specialmente focalizzatevi sul respiro che entra dal naso, riempie i polmoni, poi la pancia, e poi buttate fuori quell'aria. Sgonfiando la pancia e poi i polmoni e ora uscendo dal naso o dalla bocca. Se vi viene meglio tenete una mano sulla pancia per aiutarvi.

FARE INSIEME UN CICLO RESSPIRATORIO GUIDANDOLI NEL PROCESSO

(si ripete: naso, polmoni, pancia, poi fuori...) contare fino a 3 quando si inspira e fino a 4 quando si espira.

Ora vi chiediamo di farlo da soli. Concentratevi sul respiro. Ripeteremo questa respirazione ora per un minuto, sono circa 4 respiri. Fateli lentamente.

Attenzione concentratevi sul vostro corpo e sentitene ogni parte, potreste osservare per esempio che attraverso i respiri che fate lentamente il corpo lascia andare le tensioni e si rilassa.

Al termine di questo minuto vi chiederemo di scrivere su un foglio come vi siete sentiti quindi cercate di focalizzarvi sulle sensazioni del vostro corpo.

SIETE PRONTI? Se volete potete chiudere gli occhi per aiutarvi a rimanere concentrati.

COMINCIAMO

1 MIN

Ora piano piano riaprite gli occhi quando siete pronti. Grazie mille per essere stati pazienti e aver fatto questo esercizio!

CONSEGNARE FOGLIO

Ora sul foglio che avete davanti riportate descrivendo con più parole e dettagli che potete come vi siete sentiti durante il minuto appena trascorso. Usate il disegno se volete per aiutarvi.

AVETE DUE MIN. Cercate di rimanere in silenzio.

Appendix B: sheet given to answer the open question on what they felt during the exercise and the human body shape.

ID_____

CLASSE_____

Descrivi come ti sei sentito/a nel minuto in cui ti sei focalizzato sul tuo respiro.

Per aiutarti puoi usare anche l'immagine qui sotto indicando come ti sei sentito nelle diverse parti del tuo corpo.

