

DOCTORAL (Ph.D.) DISSERTATION

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Trauma-related neurobiological effects and risk factors
of physical injuries among professional dancers



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of physical injuries among professional dancers

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All true artists bear within themselves a deeply rooted and often unconscious desire for transformation.

Michael Chekhov

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Abstract

BACKGROUND: Professional dancers work under pressure as their job is highly demanding. Therefore, they often suffer from musculoskeletal injuries and stress-related psychopathologies like anxiety and eating disorders. Since the metoo campaign was launched abuse cases revealed within the creative industry raising questions not only sociologically or legally but also medically and psychologically. **AIM:** Understanding the psychophysiologic relation between stress and musculoskeletal injuries where stress is originated by repetitive emotional abuse. **METHOD:** We studied Hungarian professional dancers to assess what stress factors they cope with and what musculoskeletal injuries they suffer from intending to find the relation between them. In a qualitative research study (n = 13) an Interpretative Phenomenological Analysis was conducted, while in our quantitative study (n = 168) several validated psychometric questionnaires and statistical analyses were used. In a separate study on an animal model of trauma-induced stress (n = 40), a specific relationship between symptoms and connective tissue flexibility was examined with biological and physical (tensile strength) methods. **RESULT:** We found a significant relationship between emotional abuse and chronic musculoskeletal conditions such as chronic pain, inflammation, tendinopathy, and perceived stress with acute complaints located in the lower back, and other regions. The animal model showed a significant difference in the flexibility of the Achilles tendon of stressed and control groups, supporting our other results that traumatic experiences, such as emotional abuse, can make the connective tissue more vulnerable. **CONCLUSION:** Professional dancers suffer from emotional abuse, originating from an impaired way of coaching that involves generations of dancers. Emotional abuse might be a risk factor for musculoskeletal conditions, explained by the decreased flexibility in the connective tissue to tensile stress exposures.

1. Introduction

1.1. Personal involvement

At twelve, I got admitted to a professional dance academy, where I graduated with a college degree. During the five years that I spent there as a student and a teenage boy, I was under pressure, which at that time was encouraging and exciting. Years after I had finished school, I gained experience from working in different theatrical settings, where I have seen many of my colleagues suffering from different musculoskeletal conditions.

During my Ph.D. research, I was interested in the psychological and psycho-physiological background of trauma experience to investigate its role in physical conditions and to understand scientifically a phenomenon that harms hundreds of creative, beautiful, and enthusiastic artists with the hope of providing support to the dance industry for a change. Regarding my undeniable personal involvement, my supervisors were asked to reanalyze the results as outside controls in the studies. This strategy helped eliminate conflict of interest and consequent reimbursement or certain bias.

1.2. Brief introduction about abuse in dance history

The mental health of artists has been a central issue in our culture since the beginning of the Romantic movement (Trilling, 1965). Several mindsets exist regarding the path to becoming a professional dancer. One says the effectiveness of art is directly proportional to the artist's suffering (Trilling, 1965), while nowadays, the *no pain, no gain* theory describes hard work (Molnar, 2017). Enduring suffering is a test of personality—a mindset that appeared first from Aeschylus and remained in the 19th century within Christianity (Trilling, 1965).

Sex work, abuse, money, and power described the 19th-century great ballet companies' *milieu* that ballerinas had to integrate into (Blakemore, 2018). In Paris Opera Ballet, the 19th-century company leaders found talented ladies in poverty, enticing them to a promising, sparkling future called ballet. "*Petite rats*" (Kelly, 2012) were those young ladies, who firstly were trained to be great ballerinas, and secondly were sexually used as *courtesans*, serving *abonnés*, wealthy men who settled the expenses. Behind the scenes, where ballerinas had the chance to warm up, *abonnés* had their chance to socialize. This lavish room was known as the *foyer de la danse* (Kelly, 2012).



Figure 1: Jean Beraud of ballet dancers in the wings of the opera house, 1889, The lavish room known as the 'foyer de la danse'

As talents were searched among the poor, mothers usually agreed to give up their children to become 'prostitutes'. At that time, working for the Paris Opera Ballet provided advantages. Ladies were independent, dancing to their own tunes (Yung, 2020). They had the chance to live individually, learn, and earn money (Kelly, 2012). For some girls, ballet was a way out of poverty. In the 19th century, ballerinas were recognized on the same level as wealthy entrepreneurs; they had the chance to join the Jockey-Club de Paris, where gentlemen reserved boxes at the Paris Opera using them as places for sexual encounters (Kelly, 2012). This was the way how the Paris Opera's backstage became the place of institutionalized prostitution (Kelly, 2012). The ballerinas' feelings were entirely neglected, they had to do what they were told, which was usually built into their general daily dance instructions (Huckenpahler, 1984). Dancers, especially in junior positions, were not paid well. Dresses, costumes, and pointe shoes were their duty to buy and as it was not affordable from their salary, the only option was to become utilized by generous men for sexual gratification (Kendall, 1998).



Figure 2: Degas: Little dancer of fourteen years (Picture by: Colleen Barrett)

The atmosphere and the lack of well-being of these ballerinas is not only documented on paper but also appeared in several art forms. Edgar Degas was one example, with his famous sculpture, the *Little Dancer*, portraying Marie van Goethem, a fourteen-year-old ballerina. She was marked by the sordidness of the sexual harassment that was baked into ballet (Blakemore, 2018). Not only in Paris and not just in the 19th century but decades later in Russia, ballerinas' utilization was ongoing; Kschessinska was a needy but gifted ballerina, and also a courtesan of the Russian Tsar (Kelly, 2012). George Balanchine the 20th century greatest American choreographer became famous for creating the modern body idol of a ballerina; he was responsible for “*institutionalizing an image of the female dancer achievable only through the utmost deprivation, bordering on torture*” (Kelly, 2012). In the 20th century, ballerinas became anorexic and bulimic and used different types of treatment to fulfill their aesthetic requirements (Bentley, 1982). Balanchine's acolytes helped institutionalize the ideal and the eating disorders that are the direct result of its pursuit; the emphasis on thinness in female ballet dancers was an artistic imperative that penetrated the ballet world with alarming spread, producing underfed dancers with visible hip bones and prominent clavicles everywhere classical ballet was found (Kelly, 2012). George Balanchine died of Creutzfeld-Jacob syndrome in 1983, caused by a rejuvenation treatment using animal glandular products (Kelly, 2012). However, Balanchine made an imaginary ideal but severely toxic body culture, ballerinas were obsessed with him; they felt respect towards him (Gordon, 1983).

Nijinsky (1889–1950) was one of the greatest male ballet dancers of the 20th century (Phillips, 2000). From the day he joined the school, his teachers recognized his sensational talent: “*His body is perfect. The most symmetrical human I have ever seen.*” (Fernandez-Egea, 2019). With a poor family background, aiming to get involved with the aristocratic elite, and his natural talent made him become an instant target of all the other male dancers (Fernandez-Egea, 2019). As Bourman explained, “*he was made to feel inferior at every turn; he was ignored in our games, and utterly despised. He was someone to be ordered about, to be sneered at and scorned. Whether or not he deserved criticism, Nijinsky found it*”. This bullying masterclass lasted 8

years and included a somewhat unexplained accident on the stage in which Nijinsky allegedly lost consciousness for a week (Fernandez-Egea, 2019). A wealthy aristocrat, Prince Lvov, became his benefactor and probably his first partner, but he soon grew tired of Nijinsky and ‘passed him on’ to other lovers. Sergei Diaghilev (1872–1929), a dance impresario, who was gaining success in Europe, entered his life as both a lover and a key figure in his artistic career (Fernandez-Egea, 2019). Diaghilev “*handled him terribly brutal, beat him, locked him in a room when he went away, allowing him to be with nobody else until his 18th and abused him sexually*” Binswanger described. Nijinsky was diagnosed with schizophrenia in 1919. The concept of schizophrenia is explained by a complex psychological defense mechanism (Fernandez-Egea, 2019), which indicates that Nijinsky’s schizophrenia could be linked to these childhood and adult life stressors (Fernandez-Egea, 2019). Indeed, contributing to epidemiological evidences indicate that sexual, emotional, and physical trauma is an independent major risk factor for schizophrenia (Hardy et al., 2016).

1.3. Topicality of abusive atmosphere in professional dance

While we have seen that the abusive atmosphere has a historical and transcultural background, this doctoral research theme has an outstanding international topicality that must be mentioned. Since the launch of the #metoo campaign in 2017 in the United States, the professional theatrical communities have been eagerly working on self-purification. Vienna State Opera’s ballet academy was one of the first European institutions facing an abuse crisis, where students raised their voices as victims of physical, emotional, and sexual abuse (Henley, 2019). The Danish choreographer Jan Fabre and artists have been accused by twenty dancers of his company of multiple fits of abuse and a toxic work environment, one in which sexual acts were exchanged for performance time, or “*no sex, no solo*” as one performer explained it (Bradshaw, 2021). While we can assess an increasing activity in opening up abuse-cases, there are a few earlier examples, such as the Bolshoi Ballet prostitution: “*Volochkova, who was sacked in 2003 under Iksanov’s tenure for being ‘too fat,’ alleged that female dancers were forced to sleep with Bolshoi’s rich patrons or lose their job*” (Bacchi, 2014).

Hungarian examples could also be mentioned, where the former director of Operetta and Musical Theater was accused of physical, mental, and sexual abuse (Vig, 2021), or when several ballet teachers’ names working at Hungarian Dance Academy were published online in the context of sexual, physical and psychological abuse (Galavits, 2020), victimizing former ballet

students. The above-mentioned cases mostly reached the press, causing a severe reputation decline for the accused persons and victimization of those who raised their voices. To our current knowledge, there are only a few cases where legal steps were made, and even fewer cases ended with court decisions. Currently, there is no institutionalized therapy available for dancers who experienced trauma during their work or education, and no validated method to eliminate the toxic components of the work and educational environment in the dance industry. We have found only a few scientific papers dealing with professional dancers' traumatic experiences and abuse or psychological difficulties concerning their working or educational background and found no scientific results published about their possible connection with physical conditions.

1.4. Preliminary data: a qualitative pilot study

1.4.1. Introduction

Professional dance has a high physical injury rate (Air, 2013), which in several cases is attempted tried to be solved with an established medical team on behalf of the company or pre-professional dancer's teaching school. Although the injury prevalence is high, there are many unreported cases, where the reason behind the injury is varied (Jacobs et al., 2017). Famous companies like the Royal Ballet have 17 sport science and healthcare workers for 97 dancers to decrease the injury prevalence (Bailey, 2018). In Hungary this ratio is much lower: there are only a few professional dance companies hiring healthcare practitioners and if so, 1 to 3 therapists deal with 100 dancers. Dance medicine has a few decades of history. The International Association for Dance Medicine and Science has been running since 1990, aiming to "enhance the health, well-being, training, and performance of dancers by cultivating medical, scientific, and educational excellence while promoting an active network of communication between dance and medicine" (IADMS, 2021). Dance medicine and science have gained increasing interest among medical professionals and among dancers who happen to change careers after dancing. Despite the increasing interest and the number of experts dealing with dancers, the injury prevalence is not decreasing (Jacobs et al., 2017), which shows that these injuries are not only based on the overload or the lack of specific training but have a significant connection with psychological factors (Mainwaring & Finney, 2017). In this pilot study, we were interested in the connection between preprofessional dance and ~~its connection to~~ psychological abuse.

1.4.2. Method

We have conducted three interviews with healthcare professionals experienced with dancers. Two of the interviewees were dance-medicine experts, meaning they work with professional dancers as medical professionals. One of the dance-medicine experts was a physiotherapist, and one was a certified nutritionist. The third interviewee was a psychologist, a Ph.D. student who was trained to become a professional dancer. The interviews were conducted via the ZOOM online platform. Voice recording was used and later analyzed. The interviews were between 35–59 minutes. They have all clarified to accept and participate in the recording and let us use their words to further analyze and publish the results of the interview.

1.4.3. Results

In the interview, interviewees summarized the basic principles of what pre-professional education should look like. They concluded regular, well-established kinetics, appropriate mental health, and general well-being, and mentioned the lack of injuries. As they have described the ideal way of training a ballet dancer, they introduced the high number of traumatized teenagers in the educative system. It seems to be a problem that individualism is pushed to the side. Students have no right to be creative and explore themselves, which might be a consequence of how they cope with stressors and pressure. Students and professional dancers have fully packed schedules and repetitive movement structures in general. Repetitiveness was highlighted by all of the interviewees since they mentioned this to be a probable cause of losing motivation during the years. Over the lack of individuality, they mentioned that ballet teachers have limited anatomical, biomechanical, and preventive knowledge, with a very high number of misconceptions about certain medical and health-related issues. According to the interviews, this might have a great impact on injuries too. While individuality is seemingly not to be respected, the personal space is also not appropriately managed by the dancers and teachers. One of the interviewees was referring to her own experience that she—as a worker at the institute—had to subordinate her personal needs and decrease her personal space during the time she was working there to fulfill the hidden curriculum of dance. *“Subordinate everything to the goal, or it can easily turn into the source of constant conflicts.”* Students and health experts experience exhaustion, constant pressure, and infinite energy investment with minimal returns. The very high number of physical injuries has a great link to psychological demand and the low level of mental well-being, they said. Although the physical injuries get -well-demarcated attention; body perception, nutritional and digestive

pathologies are also very frequent but certainly not recognized as important as the locomotor issues within this population. Dancers feel like they must fulfill all the requirements that the ballet teacher has established, even though they might go against their physiological demands. According to dance medicine experts, parents are usually a part of the abusive atmosphere since they hide the signs of possibly harmful factors under the concept that “*a superordinary talent (their child) needs to bare some harm to achieve success*”.

During the interview, we asked the participants about the word: ‘humility’. Considering the personal involvement, we believed that this expression may be a concept of an overestimated acceptance of abuse. All of the interviewees recognized the expression immediately as a commonly used term within dance institutes and they have all clarified that the expression has an alternative, hidden meaning in professional dance, in which the boundaries can be expanded, the personal space is narrowed and the general attitude is to subordinate the dancer to fulfill the requirements.

While the number of injuries may have connections with the mental status and the constant state of readiness, the interviewees all mentioned that—in the case of dancers—injuries are sometimes meant to be an escape from emotionally unbearable situations. The physiotherapist of this study has exclusively highlighted the so-called “*silent treatment that has empirical proof to be a source of physical injuries,*” which appears regularly against those dancers whom the ballet teachers have a problem with. The most abundant physical injuries according to the physiotherapist are stress-related fractures and ligament ruptures. However, chronic pain and chronic inflammation in certain extremities are also widespread. In this community, physical injuries, chronic overload, and the lack of time for regeneration are also risk factors, along with severe qualitative malnutrition and the high prevalence of Body-Dysmorphic Disorder.

We have asked about three general types of abuse and whether our interviewees had ever experienced any kind of abuse during their time in professional or pre-professional dance. We have also asked them to differentiate the directly told by the dancers they were treating from the abuses they might have personally experienced. The results are concluded in the table below:

Table 1: Types of abuse reported by the interviewees (2020)

Type of Abuse	The interviewee personally experienced	The interviewee was directly told by the dancer
Verbal Abuse	yes	yes
Physical Abuse	no	yes
Sexual Abuse	no	yes

The frequency of the abuses was mentioned to be extremely high in verbal manifestation, while physical and sexual abuses had a lower rate of appearance. Within this category, the experts reported that these abuses mostly contained some ‘professional’ content and usually they had a threat component, which concluded the possible options of not being recruited for a show or “the dancer will have problems on the exam”. Physical abuse appeared several times, in the form of throwing objects during class to enforce silence or “to motivate dancers to work harder,” hitting or touching to cause pain “to better feel how a certain movement should be done.” Sexual abuse was only mentioned by one of the three interviewees, who clarified that these atrocities were not containing sexual intercourse; however, the intention of the verbal or sometimes physical abuse was filled with sexual content. All the interviewees highlighted that verbal abuse and—most commonly—emotional abuse were the most abundant, and that emotional trauma probably had the most significant long-term impact on dancers.

2. Research questions

1. Do professional dancers, educated and working in Hungary, experience emotional and physical abuse from their occupational atmosphere?
2. If so, is emotional or physical abuse a systemic problem that may be associated with pedagogical strategies and follows generations of dancers, or are these individual cases?
3. Do professional dancers suffer from pathological dissociation?
4. Do dancers injure at least once during their careers? Are these injuries related to emotional abuse experience in their occupational atmosphere?
5. Can abusive experiences increase the risk of connective tissue injuries? Can trauma make the connective tissue more vulnerable?

Flowchart of the research

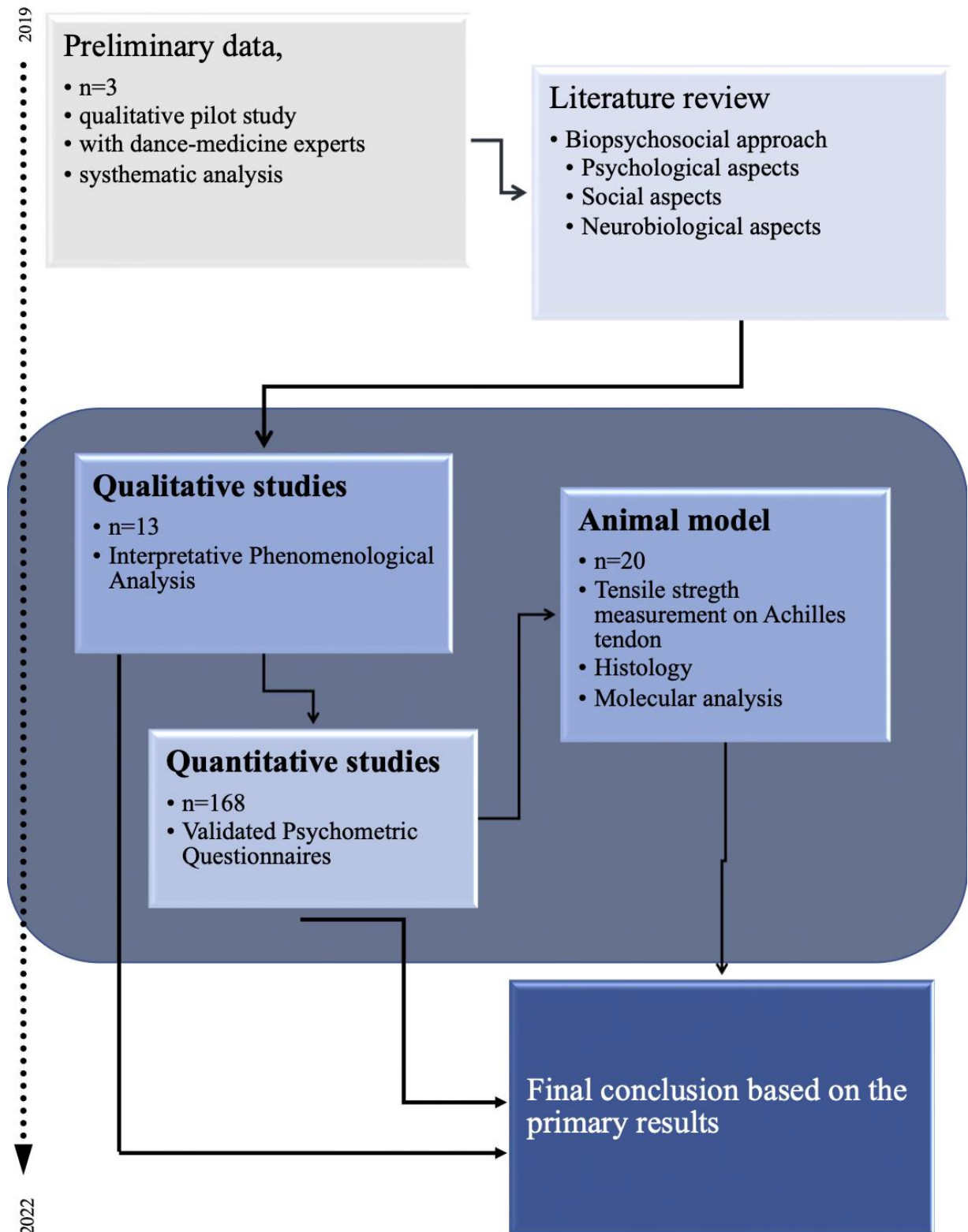


Figure 4: Flowchart summarizing the steps of this research

3. Literature review

In the literature review, the most relevant results were collected using the Bio-psycho-social approach (Frankel et al., 2003; Gatchel et al., 2007) to understand the social and psychological background of traumatic experiences and to summarize the scientific results of the physical manifestation of psychological traumas. The topic has a huge literature either from a psychological or a neurobiological point of view, so the following summary was made: Abuse that was documented and analyzed by scientific papers among dancers; aspects, that might play a role in the abuses within the dance world; the relation of trauma and dissociation. Moreover, a summary was made about the biological aspects of post-traumatic stress disorder (PTSD), such as neural, hormonal, and immunological traces. Later on, in this chapter, the Stress-Injury Model and documented dance injury rates and etiology is being described. Although the dissertation is not aiming to include all aspects of PTSD research, during the literature review we found numerous data about genetic and epigenetic results, as well as cognitive and gut-brain-microbial data, which were exciting but did not serve the further investigation discussed in this thesis.

3.1. Types of abuse documented in dancers

Dancers have a significantly higher prevalence of PTSD (20.2%) compared to the general population (7.8%) (Thomson, 2015). They also have a higher frequency of family members with mental illness, an inability to speak about their trauma, and more suicidal thoughts (Thomson, 2015). The PTSD group of dancers had higher levels of psychopathology (anxiety, depression, dissociation, and shame) and they had more childhood adversity and adult trauma (Thomson, 2015). Abuse is prevalent in the creative industry, which is considered to be a part of the occupational culture, where four factors were established: competition for work, industry culture, gendered power relations, and the importance of informal networks (Hennekam, 2017). Workers in the creative industry are in a vulnerable position since the worker's protection and the irregular income create competition and a contingent structure (Caves, 2000). Hungarian dancers have no career model (Mihályi, 2015), which could ensure dancers benefit from the work they invest in dance after their active stage career. Students learn for 5 to 10 years during their teenage years to become professional dancers, and after the active stage years, there is no well-established solution for employment of the job-lost dancers. This is consistent with Caves' (2000) and Hennekam's (2017) suggestions and serves as a factor of being vulnerable

to certain types of harassment. Power is unequally distributed in the creative industry and mainly men hold the decision-making positions (Hesmondhalgh & Baker, 2008). This may increase the likelihood of abuses since it is known to be more prevalent in organizations with large power differences (Illies et al., 2003; Katila & Meriläinen, 2002; Wilson & Thompson, 2001; Hennekam, 2017). In addition, creative industry careers are often navigated individually and have minimal opportunities for stable employment (Bennett & Bridgstock, 2015). Informal recruitment practices—employers recruit people recommended by colleagues (Skillset, 2010) or people with whom they worked already (Blair, 2009; Randle & Culkin, 2009)—were identified as a key mechanism for reproducing gender inequality and a possible source of abuses (Wreyford, 2015; Perrons, 2003). Thanki and Jeffreys' (2007) term, 'contacts culture,' describes a rather common practice of excluding unfavorable or including favorable individuals for projects. This increases the intention to fit the subjective requirements or at least become a favored contact to get the job. Relatedly, when informal networks are operationalized during casual social gatherings (Grey, 2005) the boundaries between professional life and personal life are blurred (McDonald et al., 2008).

3.1.1. Gender, stigma, and abuse

The issue of masculinity in the art of dance has attracted the interest of several researchers (Frost & Meyer, 2009; Hennekam & Bennett, 2017; Risner, 2007). Social stigma is formed quickly and is easily felt by the dancers: "*Dancing is such a gay thing!*" (Risner, 2017). The process of practical and symbolic feminization introduced by Western theatrical dance in the 19th century (Burt, 1995; Thomas, 1996) led to one of the problems of the male dancers (Adams, 2005). Hegemonic masculinity provides men with a culturally exalted role that describes what an ideal man looks like (Szemán, 2017). Brannon put it this way in 1976: "*An ideal man cannot be a smoker, but be as strong as a tree and give it his all.*" Male dancers are therefore often confronted with the claim that their work does not meet the characteristics of the "expected" male, thus, stigmatizing them (Goffman, 1959; Risner, 2017). That is, while dance is highly feminizing, it is highly stigmatizing for male artists (Risner, 2017), as femininity is still seen as the antithesis and subordinate category of masculinity (Connell & Messerschmidt, 2005; Gardiner, 2002; Messerschmidt, 2012). A complex set of norms, attitudes, and behaviors define the meaning and value system of ideal, traditional masculinity in society (Szemán, 2017). However, these systems have now evolved into more narrow, restrictive boxes (Szemán, 2017). While idealized hegemonic masculinity is heterosexual (Haltom & Worthen, 2014), the proportion of homosexuals among male dancers has been estimated to be 58% (Bailey &

Oberschneider, 1997). Anderson (2005) outlines four coping mechanisms against the feminine stigma: (a) homophobia, (b) devaluation of femininity, (c) emphasis on masculine prowess, and (d) the creation of masculine space within the larger feminized space. To accept and maintain idealized hetero-masculinity, men need to address their sexual and gender identities simultaneously (Anderson, 2005). Biology is not what gives mainstream discourse (Foucault, 1971), as socio-logic is based on it (Butler, 1990). Masculinity and femininity form two dichotomous categories with more or less appropriate and illustrative bodily characteristics, actions (movement, gesture, body, techniques, etc.), and activities (Connell 1987; Goffman, 1959). For example, young male athletes are also often in a highly gender-segregated position, which socializes them to devalue women and femininity (Anderson, 2008; Messner, 2002). Men who have danced have reported how important a real, masculine appearance on stage is to them (Haltom & Worthen, 2014), which may be due to the suppression of stigmatization on the one hand (Bassetti, 2013); on the other hand, resulting in more emotionless behavior in social intimacy and maybe the main source of a problem in dissatisfaction with relationships (Szemán, 2017). The kind of artistic ‘strategic’ solution is to work “macho,” to reinforce hetero-masculinity on stage (Fisher, 2007). This kind of male role means limiting emotions since a real man does not express his emotions (except anger and resentment), and it is associated with the expectation of homophobia, social control, power, and competition that completes the normal system of traditional masculinity with the compulsion of success (Szemán, 2017).

Risner divided the reasons why masculinity among male dancers into five groups: (a) homophobic stereotypes, (b) narrow definition of masculinity, (c) heterosexist justification of male participation, (d) lack of positive male models and heterosexuality, and (e) internalized homophobia among dance students. All of these show a negative environment for male dancers (Risner, 2007). Men who do not meet the ideal of masculinity receive immature, unmanly, feminine labels as a stamp (Szemán, 2017). Juvenile young male dancers often receive these negative, stigmatizing triggers (Haltom & Worthen, 2014). In the art of dance, the eradication of feminine lines is so strong that bullying-level instructions ‘for purely professional reasons’ may occur: “*You are a beautiful dancer, but you dance like a fag. We have to show you how a man dances*” (Risner, 2007). Bullying is a form of violence that occurs between two or more individuals (Manea, 2020) and, like aggression, can mean multiple forms of repetitive, deliberate harm to a vulnerable person in a given situation (Sudgen et al., 2010). It is a form of abuse that can cause severe personality destruction and severe trauma, and later possible PTSD (Dósa, 2018), which takes place not only between the victim and the perpetrator but also among

the observers (Dósa, 2018).

In this stigmatizing community, Haltom and Worthen described a possible distribution and coping of male dancers as an Identity theory:

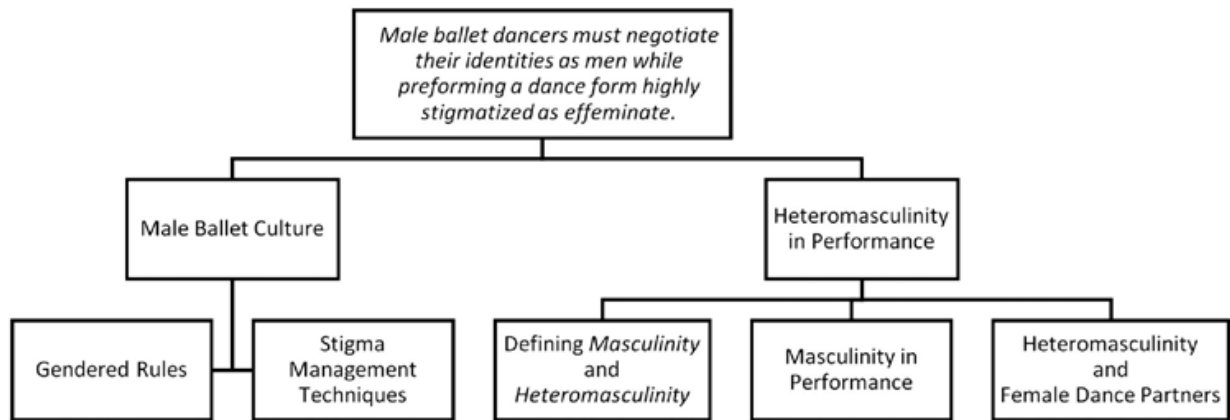


Figure 5: The identity theory of male ballet dancers (Haltom & Worthen, 2014)

Gender rules were described in ballet culture: it was found that male ballet dancers who adhered to these gender rules appeared masculine, and those who did not follow them appeared feminine, so male ballet dancers specifically defined the gender movements and techniques; for example, male ballet dancers have been called to have “good foundations” if have the power to lift others, can jump higher, and are stronger than female ballet dancers (Haltom & Worthen, 2014). Research by Haltom and his team reveals that artists have developed a complete strategy against stigmatization: (a) emphasizing heterosexual privilege, (b) comparing ballet and sports, and (c) classifying ballet as an elite art form (Haltom & Worthen, 2014). These mechanisms are not only harmful to the individual, but—as Risner has described—empower the abuse cases and provide a stressful atmosphere instead of a safe zone. Leslie and Catungal (2012, p. 118) describe that “*certain creative occupations reproduce masculinist workplace cultures and are therefore potentially harmful spaces for women.*”

3.1.2. Destructive instruction

Classical ballet dancers perform one of the most complex combinations of motor skills, often under pressure (Guss-West & Wulf, 2016). Working under pressure predisposes self-regulation, which is an important skill among athletes and professional dancers for well-being (Balk & Englert, 2020). Among elite athletes negative mood states highly correlate with their coaches’ behavior (Buning & Thompson, 2015) as an external source of motivation, which usually consists of instruction and feedback (Price & Weiss, 2000). In the ballet room, verbal instruction is the dominant activity provided by the teachers and coaches (Potrac et al., 2000;

Hodges & Franks, 2002). It is understandable as performing art requires constant kinetic learning; that is highly feedback dependent, so verbal instruction appears to be a key tool (More & Franks, 1996). Verbal instructions and feedback have for a long time been regarded as essential psychological and pedagogical competence of coaches (Holding, 1965; Chow, 2013; Button et al., 2020). Small differences in the wording of instructions or feedback given by teachers can have a significant impact on the effectiveness and efficiency of motor skill performance (Guss-West & Wulf, 2016). There are several ways to give feedback: instructive (direct) verbal communication; task-oriented communication; Q&A feedback; trial and error; (live) video feedback; model learning; and analogy learning (Otte, 2020). Positive and implicit feedback has a demonstrated enhancing effect on motor learning (Lewthwaite & Wulf, 2010), positively related to athletes' effective learning (Turman & Schrodt, 2004); athletes are more satisfied when coaches offer positive feedback to them (Dwyer & Fischer, 1990). Although positive feedback has a demonstrated positive outcome, dancers easily face destructive instructions (Gibbons, 2004). Verbal aggressiveness is destructive communication that involves attacking another person's self-concept to intentionally hurt the receiver (Infante and Wigley, 1986). Individuals who are the target of verbally aggressive messages often feel embarrassed, inadequate, and depressed (Infante, 1995), and this may lead to negative relationship outcomes, and—if they are regularly directed toward one person—it constitutes psychological abuse (Infante & Rancer, 1996). Aggressive communication has been substantially studied in communication research (Myers, 2003; Rancer & Avtgis, 2006; Schrodt & Finn, 2010). It consists of four message behaviors: assertiveness, argumentativeness, hostility, and verbal aggressiveness (Infante, 1987). Argumentativeness and verbal aggressiveness are the primary forms through which aggressive communication has been examined (Infante & Rancer, 1996).

Destructive voice is “*the voluntary expression of hurtful, critical or degrading comments regarding the current state of affairs and has the purpose of challenging the status quo in a prohibitive/destructive manner*” (Maynes & Podsakoff, 2014, p. 91). Destructive communication appears in sports and classroom contexts, where students report lower motivation and satisfaction when they perceive verbal aggression from their teachers (Myers & Knox, 2000; Myers & Rocca, 2001), and they consider these tutors less credible than those who avoid destructive communication in the classroom (Myers, 2001). Athletes tend to react negatively to verbal aggression from their coaches (Ruggiero & Lattin, 2008). Coaches and athletes both acknowledge that when critical voice is not managed properly, it can increase negativity and disparity in the team, and ultimately result in worsening team performance (Cope

et al., 2010). In sports settings, perceiving criticism from coaches can detrimentally affect athletes' trust in their coaches (Jowett & Timson-Katchis, 2005). Kassing and Infante (1999) found that athletes were less satisfied and displayed poorer sportsmanship behaviors when their coaches were verbally and physically aggressive. In competitive sports, frustration appears to be a source of aggressive communication. The frustration-aggression hypothesis (Berkowitz, 1989) proposed that frustrating events, such as a premier, arouse overt or covert aggression towards the participants responsible for this frustration. Since performing art is a competitive and challenging field (Hennekam & Bennett, 2017), the participants are rather a part of the performance climate. A performance climate is related to unfavorable outcomes such as the application of superficial learning strategies, performance anxiety, and negative developmental experiences (Ames & Archer, 1988; MacDonald et al., 2011; Smith et al., 2007). Its focus on intra-team rivalry and outperforming others also results in detrimental interpersonal consequences such as an increased conflict between peers, bullying, reduced fair play, and lower cohesion within teams (Boixados et al., 2004; De Backer et al., 2015; Ommundsen et al., 2005).

3.1.3. Toxic environment

Leaders are those individuals who influence the behavior of their followers and modify it to reach the preliminarily set goal (Robbins, 1998). Hoel et al. (2001) stated that 74% of United States employees reported either being a victim of or witnessing someone being a victim of toxic leadership.

The "toxic triangle" concept consists of destructive leaders, susceptible followers, and environmental factors (Padilla et al., 2007). There are different types of toxic managers, and in this category are not only people with psychopathological elements but also individuals whose traits are incompatible with the functions of the leader as a person (Lubit, 2004). Often narcissistic, aggressive, unethical, or mentally sick leaders can be differentiated (Lubit, 2004) where the psychopathology correlates with selfish orientation, the compromise of quality of life and destroy the organization's main goals (Padilla et al., 2007).

Goldman (2009) suggests that the behavior of the majority of toxic leaders is driven by mental and emotional disorders, while Ghaemi (2011) argues that toxic leaders would be inherently mentally ill but can function more effectively in times of crises. Theaters are full of crises (Ball, 2018), where high functionality and fast response are a must, so toxic leaders may cause harm to the individuals but there is a huge discrepancy between their problem-solving benefits, which may blur the level of toxicity from certain aspects. While Goldman (2009) says

that a toxic leader's behavior must be understood within the context of organizational culture, toxic leadership may have serious consequences on the organization and the employees, too. Toxic work environments including toxic leadership and verbal harassment severely affect the organization's productivity with negative outcomes (Anjum et al., 2018) and elevate workplace stress (Wang et al., 2020). Olafsson and Johannsdottir (2004) described the coping strategies against toxic leadership as avoiding the toxic leader, confronting them, seeking help, or doing nothing at all.

There is evidence that toxic leaders create an undesirable atmosphere that is unhealthy for both employees and the organization, which leads to endured financial, moral, emotional, and performance issues (Morris, 2019). These employees might suffer serious emotional trauma leading to temporary or permanent health issues or even suicide (Morris, 2019).

3.2. Dissociation

Dissociation is defined as a disturbance or alteration of normally integrated functions of consciousness, memory, or identity that leads also to characteristic somatoform changes (Bob, 2007; Bob et al., 2006; Hall & Powell, 2000; Nijenhuis et al., 1996; Nijenhuis, 2000; Putnam, 1989; van der Kolk & van der Hart, 1989). The concept of dissociation was not first used in connection with trauma but in its interpretation of animal magnetism (Middleton et al., 2018) and hypnosis (Dell, 2009). Its meaning referred to the division of consciousness (Van der Hart, 2009). In the 19th century, dissociation was coupled with the concept of hysteria, as integrative capacity during consciousness is narrowed: thoughts that make up a personality are unable to integrate, so they dissociate (Van der Hart, 2009; Kuritárné et al., 2018, p. 16). According to Freud hysterical amnesia is the result of an active, energy-using defensive maneuver (Dell, 2009) that protects against unacceptable desires and urges (Kuritárné et al., 2018, p. 18). Contrary to Freud, Janet's conception of dissociation means the inadequacy of the information processing system, so the question arises as to whether dissociation can be considered a deterrent or a collapse of defense (Kuritárné et al., 2018).

Van der Hart's structural dissociation is based on Janet's theory (Kuritárné et al., 2018). Structural dissociation factualizes the division of personality that arises as a result of traumatic events and is interpreted as an integrative deficit (Kuritárné et al., 2018). Traumatic structural dissociation means the permanent division and dissociative organization of the personality, in

which the personality is divided into specific psychobiological subsystems and parts of the personality (Kuritárné et al., 2018, p. 14.; Van der Hart et al., 2006).

The dissociative personality is composed of subsystems: The apparently Normal Part of the Personality (ANP) and one or more Emotional Parts of the Personality (EP) (Kuritárné et al., 2018). Although both have blind spots in autobiographical memory with nonrealization, EPs include traumatic memories and trauma-related defense systems, while the ANP is afraid of traumatic memories, avoids them, and focuses on everyday tasks (Kuritárné et al., 2018). Because ANPs detach traumatic experiences, they can function at very high levels while having multiple deficiency symptoms, including alienation, dullness, and amnesia of traumatic autobiographical memories (Kuritárné et al., 2018).

Dissociative symptoms manifest a structural division of personality. Symptoms are grouped according to two aspects: Positive and negative, psychoform and somatoform; so this model (like BNO 10) classifies both conversion symptoms and intrusive somatic trauma resuscitation as dissociative symptoms (Kuritárné et al., 2018, p. 19.). Thus, structural dissociation can be applied to all trauma spectral disorders (acute stress disorder, PTSD, complex PTSD, and dissociative disorders) (Kuritárné et al., 2018, p. 19.).

Dissociative disorders (DID) are not uncommon, the incidence of depersonalization disorder in the average population is 0.8% to 2.8% based on research in different countries, and the incidence of dissociative amnesia is 1.8–7.3% (Kuritárné et al., 2018, p. 21.; Siegel et al., 2011). DID occur in 1.1–1.5% of the average population, but this number can range from 0.8% to 5.4% in hospital psychiatric patients (Brand et al., 2016). Dissociation disorders show a similar frequency as schizophrenia, bipolar affective disorder, or obsessive-compulsive disorder, yet are underdiagnosed (Kuritárné et al., 2018, p. 23.).

Thomson et al., (2009) examined the degree of dissociation in a group of professional performing artists, where they found that the interpreters of creative works (actors, opera singers, musicians, directors, and dancers) employed dissociation more frequently and intensely as compared to generators of new creative works (writers, composers, designers, choreographers), and many generators and interpreters endorsed dissociative experiences at the clinical pathological range. Dissociative tendencies among Rhythmic Gymnasts and dancers were similar, but different from controls (Thomson et al., 2009), while dancers reported significantly more experiences of feeling their bodies not belonging to them. Individuals from the two elite populations scored in the pathological range for dissociative disorders (Thomson et al., 2011).

Individuals with a history of childhood abuse showed employed dissociation as an adaptive coping strategy (Foote et al., 2006). Dissociative behaviors may then generalize to the stress demands encountered in elite performance settings, especially for athletes or dancers with childhood abuse histories (Leahy, Pretty, & Tenenbaum, 2008). In another study by Thomson (2013), the relationship between shame, past traumatic events, and dissociation was assessed, where dancers had increased shame and dissociation in comparison to athletes, and males had more traumatic experiences and increased dissociation relative to females. In the regression analyses, being a dancer, traumatic experiences, and shame predicted dissociation (Thomson et al., 2013). Although Thomson's study did not describe the subscales of shame, Vizin et al. (2016) found a positive association between bodily, behavior, and characterological shame among verbally abused patients.

Complex trauma has a potentially devastating effect on developing children, yet some children may be able to function effectively and competently in a variety of areas (Kendall et al., 1993; Masten et al., 1998). Dissociation can be an adaptive, active mental skill that athletes use to enhance performance in high-stress situations (Thomson et al., 2011). Trauma may not result in the same effects on all victims. Some of the victims will be resilient, which several factors were found to assist: (a) Positive attachment and good relationships with emotionally supportive and competent adult family members or adults living in the child's environment; (b) development of cognitive and self-regulatory abilities; (c) positive beliefs about the child's self; and (d) motivation to act effectively (Luthar et al., 2000; Masten, 2001). In addition, other factors play a role in the development of resilience: creativity and spirituality, degree of self-control and autonomy (Werner & Smith, 1992), and environmental factors such as a supportive family that provides structure and belonging to the community (Masten & Coastworth, 1998).

Dissociation can be used by athletes to focus their attention externally and distract from internal feelings of pain or fatigue (Silva et al., 1989)—a methodology commonly used by endurance athletes (Birrner et al., 2010; Scot et al., 1999). Elite athletes can withstand competitive, personal and, organizational stressors associated with sports by “remaining fully focused on the task at hand in the face of distractions” (Sarkar et al., 2014). Thomson et al. (2011) reported that dissociation may enhance performance in the short term and simultaneously indicate a non-adaptive response to stress and/or a way to manage unresolved past experiences. The stronger the severity of the complex trauma, the stronger the coping strategy can be observed: sublimation, humor, altruism, and repression, which contribute greatly to positive mental health and a functioning lifestyle (Kuritárné et al., 2018, p. 55.). In contrast, the use of primitive

defense mechanisms, for example, dissociation, projection, passive aggression, or hypochondria, develop severe dysfunction and worsening psychopathology can be assessed over time (Kuritárné et al., 2018, p. 55.).

Dissociation is one of the main features of complex trauma in childhood, which in the chronic case of the child relies more and more on dissociation in the treatment of the traumatic experience, thus leading to behavioral and emotional regulation problems and self-image disorders (Kuritárné et al., 2018, p. 55). Positive symptoms of dissociation: A sudden interruption of the flashback and/or conscious experience caused by an aspect of identity that was not previously part of the person's consciousness or social interaction disrupts the person's normal interactions and presents as intrusive symptoms, while the negative symptoms interfere with normal conscious functioning with deficiency symptoms that affect self-esteem, memory, and/or the ability to perceive and control different parts of the body (Kuritárné et al., 2018, p. 117).

Dissociation has been associated with several biological markers using Dissociation Experience Scale (DES) (Bernstein et al., 1986) as a measurement tool for left hippocampal volume depletion in women (Stein et al., 1997) and the level and metabolites of the neurotransmitter in the spinal fluid (Demitrack et al., 1993). C-reactive protein (CRP), a marker of systemic inflammation, has been associated with psychiatric disorders including major depressive disorder (MDD) and post-traumatic stress disorder (PTSD) (Powers et al., 2019). The findings suggest that dissociation symptoms among those with a history of trauma may be particularly associated with higher levels of inflammation (Hyland et al., 2019). The same individuals may also have a biological predisposition toward dissociation that is expressed by a gene-environment stress interaction (Nijenhuis & den Boer, 2009).

3.3. Traces of trauma in neural tissues

Abuse alters neurochemical activation, prevents neural proliferation, and causes changes in the nervous system, which create new connections providing a base for mood, recognition, and behavior alterations (Rossouw, 2012).

Posttraumatic stress disorder (PTSD) affects millions of people globally (Kessler et al., 2017), therefore psychological trauma is a current epidemiological issue (Lowe et al., 2015). The source of psychological trauma may vary on a wide scale from different types of accidents through abuse, child neglect, bullying, and mobbing to war traumas (National Collaborating

Centre for Mental Health (UK), 2005). Different types of trauma sources may cause more harm than others. The Diagnostic and Statistical Manual of Mental Disorders (DSM V.) clarifies the psychological diagnostic criteria of PTSD, which is characterized by intrusive memories of a traumatic event, avoidance of trauma-related circumstances, hyperarousal, and negative alterations in mood and cognition (American Psychiatric Association, 2013), nightmares, and somatosensory flashbacks (Giotakos, 2020) while it is also frequently comorbid with depression and other psychiatric disorders (Rytwinski et al., 2013; Spinhoven et al., 2014). The likelihood of the development of PTSD after trauma is influenced by various factors (American Psychiatric Association, 2013).

Early abuse and neglect can deregulate the child's developing neurobiological system, by reducing its resistance to stressful events, and leading to later problems of emotional regulation (Schore, 2003). People experiencing childhood and adolescent abuse and neglect tend to enter environments that put them at a higher risk of adversity during adulthood (Brown et al., 2008). The current neuro-biological understanding of PTSD highlights abnormalities in fear learning, threat detection, executive function, emotional regulation, and contextual processing in the development of PTSD (Shalev et al., 2017). According to the World Mental Health survey, considering all countries, 70.4% of the respondents reported at least one traumatic event and 30.5% reported four or more traumatic events (Benjet et al., 2016).

Multiple areas of the brain show significant differences in traumatized patients (Harnett et al., 2020). These structures are the corpus callosum, the hippocampus, the amygdala, the prefrontal cortex, and the anterior cingulate cortex (Logue et al., 2018). Harassment at a young age can cause more serious changes in the brain such as decreasing cerebral volume, shrinkage of brain chambers, and alteration of the neural connection in the prefrontal cortex (De Bellis et al., 2003). EEG scans of childhood abuse victims showed twice as many abnormalities than adult victims (Ito et al., 1993). The mentioned results in this chapter mostly dealt with war traumas, accidents, sexual and physical abuse, childhood neglect, and types of trauma that certainly have a great impact on the brain, and there are fewer or no results about pure emotional trauma experience and brain structure alterations. This viewpoint does not exclude the possibility that emotional abuse would not cause detectable alteration in the human brain. Regarding the hippocampus, it seems that this area has the highest interest in research related to PTSD, while the amygdala and prefrontal cortex are also widely studied areas within traumatized patients. Although the corpus callosum was studied in a particular number of studies, the least amount of results was found about the white matter. We have summarized only the

structural alterations in the table below, however functional changes are also documented in several studies:

Table 2: Structural changes in the human brain due to traumatic life event

Grey matter				
Brain structure	n	Result	Etiology	Reference
Hippocampus	33	19% reduction	in patients with PTSD due to childhood sexual abuse compared to the control group.	Bremner et al., 2003.
	32	18% reduction	among childhood sexual and physical abuse victims compared with the control group	Vythilingam et al., 2002.
	229	left corneal ammonis 3 (CA3) volume depletion (dendritic atrophy)	stress induced between 12 and 17 years of age	Malhi et al., 2019
	147	decreased hippocampal volume	among veterans with a diagnosis of PTSD,	Young et al., 2019
	1868	there is a relationship between PTSD and hippocampal volume decrease		Logue et al., 2018
Amygdala	15	5.1% reduction	PTSD following childhood trauma	Carrion et al., 2007
	182	significant decrease in the basal region	in childhood abuse patients	Nogovitsyn et al., 2020
	35	a relationship between smaller amygdala volume, increased levels of fear conditioning, and excessive	mice experiment	Yang et al., 2008

		glucocorticoid stress response		
	69	recess was found in the right dorsal region	in veterans with severe PTSD symptoms	Akiki et al., 2017
	22	no significant difference	among PTSD victims	Fennema-N. et al., 2002
Prefrontal cortex	42	smaller in the dorsolateral, medial, and orbitofrontal areas	in children who have been physically abused	Hanson et al., 2010
White matter				
	115	17% volume reduction	among childhood abuse victims	Teicher et al., 2004
	183	in rostrum and isthmus, a significant decrease in volume	among PTSD victims of childhood trauma	De Bellis & Keshavan, 2003
Corpus Callosum	18	a significant decrease was found in the middle-posterior body area	in PTSD patients of childhood abuse	Kitayama et al., 2007
	3047	destruction in tapetum	in PTSD victims	Dennis et al., 2019
Inferior Longitudinal Fasciculus	51	significantly lower fractional anisotropy, altered microstructure	in childhood abuse	Olson et al., 2020
Cingulum	41	posterior cingulum bundle alteration features PTSD	veterans with PTSD	Kennis et al., 2015

Regarding the research topic and special study population our main interest was the cerebellar results in PTSD patients, although recently it is not only associated with motoric skills but fear prediction and learning (Ernst et al., 2019; Lange et al., 2015) and the storage of fear memories (Frontera et al., 2020). The cerebellum has been recently recognized as a crucial structure for cognition (Sokolov et al., 2017), emotion (Adamaszek et al., 2017), and reward

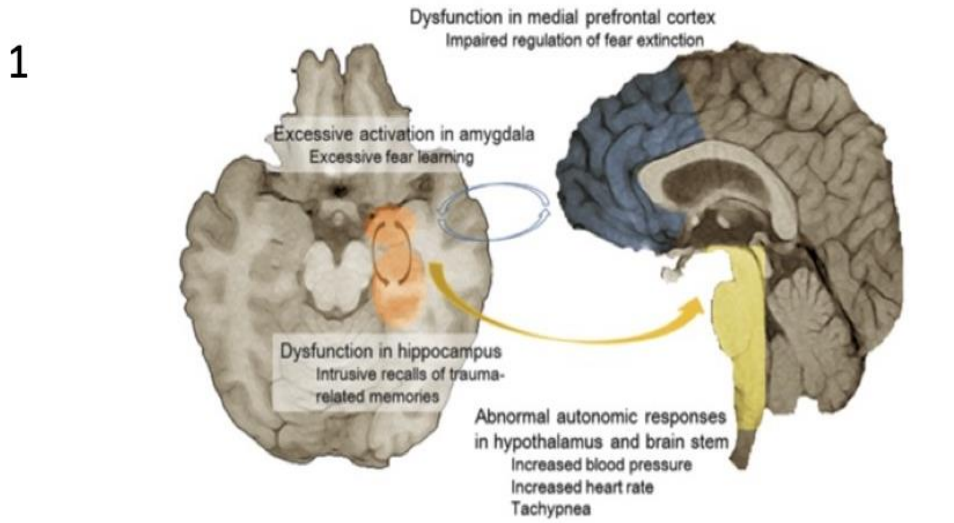
(Hull, 2020; Sendhilnathan et al., 2020; Wagner et al., 2017), beyond its well-established role in sensorimotor learning (Shadmehr et al., 2010). We found fewer data aiming to discover the effect of trauma on the cerebellum, which we summarized in Table 3.

Table 3: Cerebellar alterations found in the literature caused by traumatic experiences and PTSD

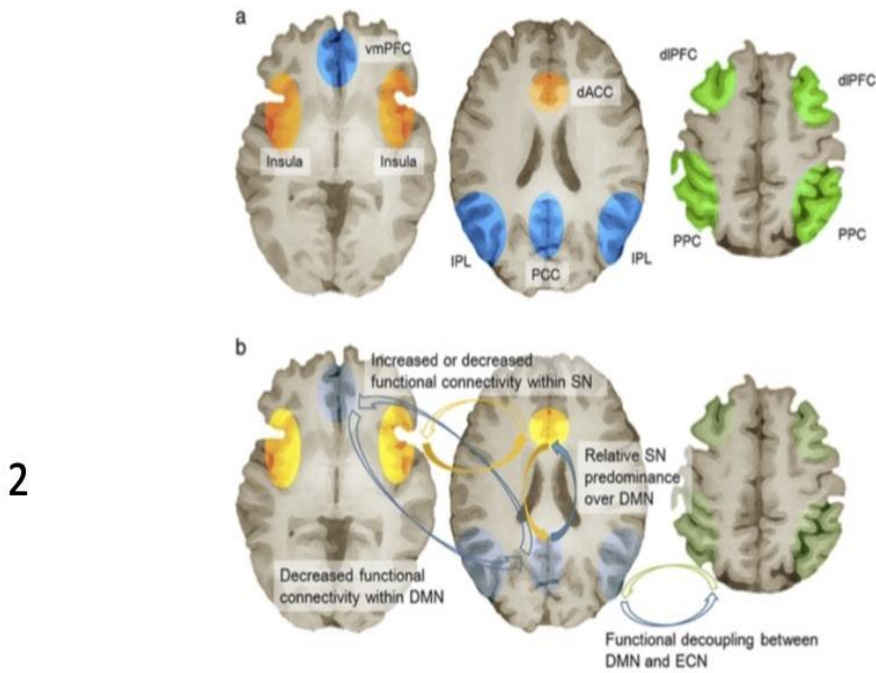
Cerebellum			
Structure	Result	Participants	Reference
General volume	Reduced	PTSD individuals	Baldaçara et al., 2011
Left hemisphere			
Vermal volume			
Vermal volume and PTSD symptoms severity, depression, and anxiety	Negative correlation	Early traumatic life events	
Right C. Crus	Decreased	PTSD individuals	Holmes et al., 2018
Vermal lobules VI, VIII, IX: gray matter density	Increased	Female rape survivors with PTSD	Sui et al., 2010
Vermal lobules: VIIB, VIIIA, B gray matter density	Increased	Male combat PTSD patients	Sussman et al., 2016
Cerebellar volume	Decreased	Neglected children and young adults with PTSD	De Bellis et al., 2003
Vermis	Morphological changes	Sexually abused PTSD	Anderson et al., 2002

Dysfunction of the neural system is thought to play a prominent role in the pathophysiology of PTSD: Fear learning, threat detection, executive function, and emotion

regulation, and contextual processing functional abnormalities have been found in patients with PTSD (Kunimatsue et al., 2019).



Kunimatsu et al.: MRI Findings in PTSD



- 1) Schematic drawings of abnormalities potentially associated with "fear circuitry" in patients with PTSD. An open arrow indicates weakened functional interactions and a solid arrow indicates overly activated interactions (Kunimatsu, et al., 2019)
- 2) Schematic drawings of intrinsic brain networks potentially associated with PTSD. a: Normal anatomy. b: Impaired activations and interactions within and between networks reported in the literature. dACC = dorsal anterior cingulate cortex, dIPFC = dorsola (Kinumatsu et al., 2019).

Figure 6: The figure shows the functional alterations in PTSD (Kunimatsu et al., 2019)

Amygdala activation is often elevated in PTSD patients compared to healthy controls, suggesting PTSD is linked to amygdala “hyperactivity” (Hayes et al., 2012; Patel et al., 2012). However, amygdala “hypoactivity” with ventromedial PFC “hyperactivity” is observed in a dissociative subtype of PTSD (Hopper et al., 2007; Lanius et al., 2010). Functional connectivity from the dorsolateral PFC to the amygdala is greater in those with the dissociative subtype of PTSD than in those with typical PTSD symptomatology (Nicholson et al., 2015). Studies show diminished ventromedial PFC activity in PTSD patients during emotional tasks (Garfinkel et al., 2014; Hayes et al., 2012; Rougemont-Bücking et al., 2011). This result can be associated with heightened emotional reactivity and extinction learning deficits (Harnett et al., 2020) moreover the failure to suppress fear responses (Milad et al., 2009) observed in PTSD, because the dorsolateral and dorsomedial PFC support the formation and expression of learned fear responses (Knight et al., 2004; Milad et al., 2007). The dorsolateral PFC activity is attenuated in PTSD patients when emotional stimuli was administered, which is associated with greater PTSD symptom severity (Aupperle et al., 2012). PTSD patients show reduced hippocampal activity during fear learning and other declarative memory tasks (Carrión et al., 2010; Hayes et al., 2011; Milad et al., 2009) most probably resulting in a relationship with disruption of fear learning and memory processes (Harnett et al., 2020).

In the PTSD group increased perfusion in large confluent regions of the cerebellum was found (Bonne et al., 2003), where depressive symptoms correlated with cerebellar perfusion (Bonne et al., 2003). Moreover, increased cerebellar glucose absorption in a group of war veterans with PTSD has been reported (Molina et al., 2010). Childhood maltreatment was positively associated with activation in the cerebellar vermis and negatively associated with activation in the left central lobule and the right posterior cerebellum in a sample of war veterans (Insana et al., 2016). Increased functional connectivity between the left cerebellar lobules IV-V, the right fusiform gyrus (FFG), and the hippocampus was found nevertheless the right cerebellar lobules IV-V and the right posterior insula and the planum polare in individuals with PTSD showed similar results (Rabellino et al., 2018). Individuals with PTSD showed lower whole-brain connectivity in the right cerebellar Crus, dorsolateral prefrontal cortex (dlPFC), and medial prefrontal cortex (Holmes et al., 2018). A significant negative correlation was found between intrinsic connectivity distribution in the cerebellar vermis and PTSD symptomatology (Holmes et al., 2018).

In the last few decades, vigorous efforts have been made to organize various findings reported on PTSD into an integrated biological PTSD model (Kunimatsu et al., 2019). The

biological representations of PTSD encompass neurophysiological measures, neuroimaging findings, neurochemical substances, gene alterations, and epigenetic regulations (Pitman et al., 2012).

3.4. HPA axis alteration in PTSD

Alterations within the hypothalamic-pituitary-adrenal (HPA) axis are suggested to accelerate chronic disease progression in the PTSD population (Miller et al., 2007). Cortisol is a glucocorticoid-type hormone that can represent alterations to HPA axis functionality, particularly with its diurnal rhythm (Speer et al., 2019). The diurnal (i.e., circadian) rhythm of cortisol follows a 24-hour cycle, with a peak hour of waking, declining during the day, and a bottom-line rate during sleep (Morris et al., 2012; Ryan et al., 2016). Alterations to this rhythm, abnormal diurnal cortisol, may alter homeostasis and dysregulated HPA axis functioning (Daskalakis et al., 2013; Morris et al., 2012).

Several studies have exhibited lower-than-normal diurnal cortisol secretion in PTSD patients (Bremner et al., 2007; Clow et al., 2010; Cordero et al., 2017; de Kloet et al., 2007; Eckart et al., 2009; Gill et al., 2008), and some studies detected no significant differences between PTSD patients and healthy controls (Labonte et al., 2014; Metzger et al., 2008; Pierce and Pritchard, 2016; Van Liempt et al., 2013; Wahbeh & Oken, 2013). Gill et al. (2008) found that dysregulated HPA axis functioning via lower morning cortisol levels was correlated with PTSD hyperarousal symptoms, while some studies have proposed that trauma exposure and more precisely, the number of traumatic events correlates with cortisol concentrations (Eckart et al., 2009; Johnson et al., 2008; Pierce & Pritchard, 2016). In PTSD patients, a “flat” diurnal cortisol profile was detected, which show a reduced cortisol awakening response (CAR) that was followed by a sudden decrease after a 30-minute awakening and then a significant increase during the day and a lesser drop in levels over the night was characteristic (Lauc et al., 2004).

The results are truly heterogeneous. Several studies found no statistically significant differences in diurnal cortisol levels between the PTSD group and the non-PTSD but trauma-exposed control group, which attributes decreased cortisol concentrations as more likely linked to trauma exposure than PTSD itself (de Kloet et al., 2007; Metzger et al., 2008; Pierce & Pritchard, 2016, Van Liempt et al., 2013). Hypothalamic-pituitary-adrenal axis dysregulation was associated with PTSD in other studies as well (Cordero et al., 2017; Wahbeh & Oken, 2013)

while some results show partial associations indicating altered diurnal cortisol concentrations in the PTSD populations at specific time points or in experimental circumstances (Speer et al., 2019). Sample taking also shows heterogeneity with plasma or cortisol level analysis (Bremner et al., 2007, de Kloet et al., 2007; Van Liempt et al., 2013) while the inclusion criteria and the diagnosis of PTSD also varied in the literature (e.g., structured interview with a psychologist vs. self-report) (Speer et al., 2019).

Although trauma exposure seems to have a role in HPA axis dysregulation, we found a lack of homogenous results related to various regulatory roles of cortisol, which may have an impact on other physiological processes such as glucose metabolism, digestion, inflammation, and memory encoding/retrieving (Meewisse et al., 2007; Reul & Nutt, 2008).

3.5. Traces of trauma in the immune system

Individuals with PTSD, have a higher medical burden, with increased rates of cardiovascular disease, metabolic syndrome, diabetes, autoimmune diseases, and early mortality, suggesting widespread physical manifestation of PTSD (Hammamieh et al., 2012; Zoladz et al., 2008; Daskalakis et al., 2013; Ariel et al., 2017).

Based on the available literature results we have created a table about the immunological factors, that had a proven role in PTSD or which were proven to alter in PTSD/trauma-exposed patients. We have created two main subgroups: 1) The pro-inflammatory markers and 2) anti-inflammatory cytokines. Proinflammatory and anti-inflammatory cytokines play a role in the regulatory processes of oxidative stress and inflammation (Kim et al., 2020). Proinflammatory cytokines promote and induce inflammation while anti-inflammatory cytokines inhibit the synthesis of proinflammatory cytokines, and are therefore also described as inhibitors of inflammatory mediators (Dinarello, 2000). Although we found data that suggested that trauma exposure itself, irrespective of the presence/absence of PTSD diagnosis, can lead to increased levels of proinflammatory markers (Tursich et al., 2014), numerous literature results are stating that PTSD is associated with elevated levels of these markers beyond the possible effect of trauma exposure itself when they compared the trauma-exposed PTSD diagnosed group with trauma-exposed non-PTSD diagnosed individuals (Lindqvist et al., 2017; Bruenig et al., 2017; O'Donovan et al., 2017; Miller et al., 2018).

The table summarizes the name of the markers, the direction of the changes, the number of the study population (n) included, the etiology of the trauma if it was available, and the results that mainly summarize the conclusion.

Table 4: Immunological factors reported in PTSD patients

Inflammatory markers in PTSD					
Name of the immune factor	Direction of change	n	Etiology	Result	References
Proinflammatory markers					
C-reactive protein (CRP)	increase	3049	PTSD diagnosed	higher odds for elevated CRP than non-PTSD	Spitzer et al., 2010
		15	PTSD and healthy control	Positive relationship	Miller et al., 2001
		2692	low socioeconomic population with PTSD symptoms	One SNP in CRP gene sig. associated with increased PTSD symptoms	Michopoulos V et al., 2014
		735	veterans with PTSD symptoms	Current PTSD showed sig. higher hsCRP and WBC than the control	O'Donovan et al., 2017
Interleukin-6	increase	211	PTSD and healthy volunteers	stress-induced secretion of proinflammatory cytokines is involved in the catecholaminergic modulation of anxiety reactions	Maes et al. 1999
		83	soldiers with sleep deprivation	high PTSD group has a higher concentration than low-PTSD group	Devoto et al., 2017
		82	PTSD patients	PTSD may present an activation of the immune system, which may lead to neuroinflammation	de Oliveira et al., 2018

		105	childhood maltreatment and adult interpersonal violence PTSD and control	elevated IL-6 is associated with PTSD and lower cognitive function	Imai et al., 2018
IL-1 β	increase	19	combat-related PTSD	IL-1 beta levels did not correlate with cortisol levels, the severity of PTSD, anxiety, and depressive symptoms, but did correlate sig. with the duration of PTSD symptoms	Spivak et al., 1997
		19	combat veteran	High levels of CSF IL-6 may reflect neurodegeneration or compensatory neuroprotection	Baker et al., 2001
		77	women with PTSD	suggest that psychological recovery is associated with normal levels of inflammatory biomarkers	Gill et al., 2013
IL-2	increase	110	African Americans with PTSD and control	psychosocial stress may alter global and gene-specific DNA methylation patterns potentially associated with peripheral immune dysregulation	Smith et al., 2011

TNF- α	increase	167	combat veterans	PTSD symptom severity is positively associated with higher TNF- α levels	Dennis et al., 2016
IFN- γ	increase	39	combat veteran	significantly higher in PTSD patients	Zhou et al., 2014
		101	intimate partner violence	partially explain the association of mental health symptoms with physical health	Woods et al., 2005
Anti-inflammatory cytokines					
IL-4	none	30	PTSD and healthy controls	no significant difference	Zhou et al., 2014
IL-10	decreased	65	Victims of assault	Individuals with PTSD presented lower IL-10 levels than the trauma-exposed individuals without PTSD	Teche et al., 2017

3.6. Injuries in dance

3.6.1. Rate of injury

Prospective results confirm high rates of musculoskeletal injuries and pain in dancers at all skill levels (47.1%–69%) (Jacobs et al., 2017; Bronner et al., 2018). The self-reported rate of injury among adolescent pre-professional dancers has been cited as high as 4.7 injuries per 1000 dance hours (Luke et al., 2002). Comparisons between professional dancers and professional athletes indicate similar rates of injury (Knowles et al., 2006; Shah et al., 2012), although studies also indicate lower injury rates per 1000 hours of exposure in dancers compared to athletes (Bronner et al., 2018). This injury rate is similar to that reported in other adolescent sports, comparable to youth indoor soccer (4.5 injuries/1000 h) (Emery, 2006), and higher than elite adolescent gymnastics (2.6 injuries/1000 h) (Kolt et al., 1999). Injuries for both athletes and dancers may be career-ending and may lead to significant cognitive, motor, and physiologic disabilities (Bahr et al., 2003).

There is a high probability that dancers will experience at least one injury in their careers (Rietveld, 2013) while professional dancers will likely experience at least one injury every year (Ramkumar et al., 2016). Adult professional ballet and modern dancers aged 17 to 55 years injure 0.51–4.4/1000 h (Shah et al., 2012; Nilsson et al., 2001; Bronner et al., 2003; Allen et al., 2012). Between 42.1% and 77% of ballet students aged 9 and 20 years have reported being injured at least once during their training (Gamboa et al., 2008; Laenderson et al., 2011; Ekerger et al., 2014).

3.6.2. Sites of injury

Cartilages in the years of puberty show more susceptibility than in adulthood (Flachsmann et al., 2000). Loosing flexibility as a risk factor was hypothetically mentioned to be connected with the discrepancy between bone growing faster than ligament. (Stracciolini et al., 2015; Steinberg et al., 2014). Soft tissue injuries increase in frequency as the young dancer grows (Stracciolini et al., 2015), the ligament and tendon injuries increased in frequency with increasing age (from 4% in 8 to 10-year-olds to 13.7% in 16 to 18-year-olds) among young dancers of all disciplines (Steinberg et al., 2013). The lower extremity has been repeatedly reported as the most common site of injury in pediatric dancers, including all dance categories and ages (Steinberg et al., 2013, 2014, 2011; Stracciolini et al., 2015; Steinberg et al., 2014, 2011). A study assessed American ballet students between the age of 9 and 20 years where they found the most injuries at the foot/ankle (53%), followed by the hip (21.6%), knee (16.1%), and

back (9.4%) (Gamboa et al., 2008). In a Swedish dancer population of 476 ballet students between the age of 10 and 21, 76% of injuries occurred in the lower extremity and 51.6% of those at the foot/lower leg (Leanderson et al., 2011). These results are similar to the ones found on British ballet students aged 15 to 19 where the majority of injuries (77%) were within the lower extremity, 33% in the ankle, 22% in the lower leg, 20% in the foot, 13% in the knee, and 10% in the hip/groin (Ekerger et al., 2014), also to injuries in their supporting ligaments, particularly at the ankle (Lindsay et al., 2017).

While bone injuries appear to be less common, stress fractures of the lumbar spine are worth mentioning, because they have been found in 10% of all stress fracture cases in 15 and 19-year-old dancers (Lunden et al., 1999).

The commonly found tendons, ligaments injuries (Emery et al., 2006; Gamboa et al., 2008) are connected to ankle sprains and tendinosis, more precisely to the flexor hallucis longus, the Achilles, or the peroneals (Nilsson et al., 2001), ankle synovitis/impingement/bursitis (8.7%) and ankle tendon injury (7.1%) (Ekerger et al., 2014). 11.3% of dancers suffer from tendinopathy and 10.4% from patellofemoral pain which cases are also mentioned as “lower leg overuse injury” where shin splints are the most abundant type of overuse injury (Yin et al., 2016).

3.6.3. Etiology of injuries

The majority of studies regarding the etiology of injuries among dancers assessed classical ballet dancers (Smith et al., 2015). Classical ballet “*involves repetitive movements in non-physiologic positions that require significant neuromuscular control and balance, which places heavy loads on the joints and their supporting structures*” (Roberts et al., 2013; Leanderson et al., 2011; Gamboa et al., 2008). Overuse injuries were reported higher in preprofessional ballet dancers (75%) (Leanderson et al., 2011; Gamboa et al., 2008), than in adult professional ballet dancers (66%) (Smith et al., 2015).

Extrinsic risk factors, mentioned to be the background of dance injuries, include poor technique, improper training, inappropriate scheduling to prevent fatigue, lack of strengthening to prevent muscular imbalances, and suboptimal equipment, such as footwear and floor type (Russel et al., 2013), as well as social support, financial and medical availability, and cultural climate of the team or company (Thomson et al., 2020). Other factors, such as floor conditions, environmental temperature and humidity, footwear, collisions, nutrition, and sleep behaviors (Manchester et al., 2006), may also contribute to injuries.

Although many studies examine the extrinsic risk factors, there is no report to make definitive conclusions about the exact extrinsic risk factors for musculoskeletal injury in dancers

(Lindsay et al., 2017). Endogenous (intrinsic) factors (genetics, training to manage biomechanical forces, gender) also influence injury risk; for example, individual appraisal of genetic risk, trait anxiety, and attentional processes may either increase or reduce stress responses (Thomson et al., 2020; Manchester et al., 2006).

There were little evidence sampling dancers, suggesting that previous injury, insufficient psychological coping skills, low body mass index, poor aerobic capacity, and perfectionism may be associated with increased risk of injuries in dancers (Kenny et al., 2016), but athletes injury prevalence is described by the stress-injury model (Williams, 1998), suggesting that psychological stress can also be a risk factor.

The stress-injury model identifies stress as a significant risk factor for injury (Thomson et al., 2020). Although it is a fairly aged model, it remains the most dominant explaining the connection between psychological factors and injury risk (Appaneal et al., 2013). *“Athletes under psychological stress were significantly more likely to sustain acute injuries while performing, and that the influence of psychological variables on injury incidence is primarily through stress (i.e., distress)”* (Williams, 1998).

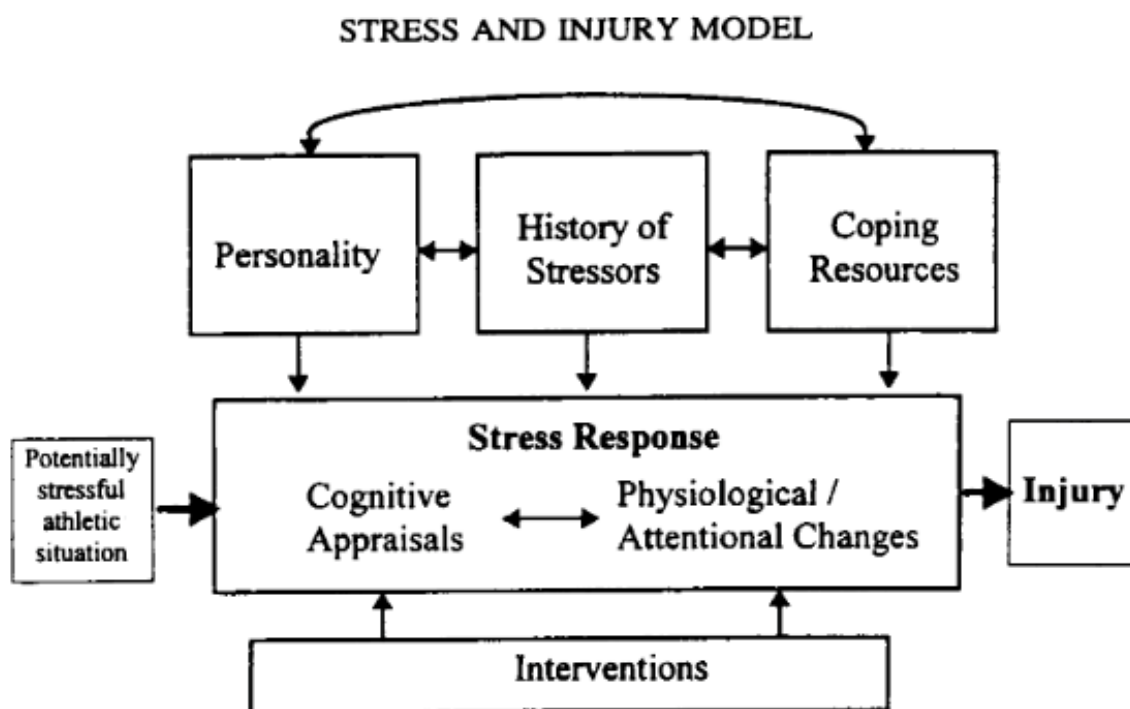


Figure 7: The Stress and Injury Model (from Psychosocial antecedents of sports injury: Review and critique of the stress and injury model by J.M. Williams and M. B. Andersen, 1998)

Williams and Andersen's model mentions four moderators, central components of the stress and injury relationship: Personality, history of stressors, coping resources, and cognitive interventions (stress management skills), which influence the risk of injury (Williams, 1998). The stress response process is bidirectional: (1) The occurring cognitive appraisal, and (2) the subsequent effects of that appraisal on attention/concentration or physiological activation (Shapiro et al., 2020).

In cognitive appraisal, we can find two subcategories: Primary appraisal in which people evaluate the environmental demand by sizing up that demand such as threat, harm, and consequence, and secondary appraisal, where they use different resources to meet that demand (Appaneal, 2013; Lazarus et al., 1984). *“If an athlete thinks that an event is threatening with severe consequences (e.g., “If I don’t stick to these routines then I will not make the Olympic team and I will lose my endorsements”) and that they do not have the resources to meet this demand (“I don’t have enough coaching support to perform well here”), then there will be a subsequent change in the athlete’s attentional field (narrowing; i.e., “tunnel vision”) and potentially delayed decision-making with an increase in physiological activation”* (Shapiro et al., 2020). This physiological activation can result in increased muscle tension, increased sweating, and decreased coordination (Shapiro et al., 2020). Both attention deficit and physiological changes greatly increase the risk of injuries (Shapiro et al., 2020). Williams and Andersen summarized that social support might be a buffer of stressful life events as positively acting on injury prevalence, while low social support makes the harmful effects of life stress worse, which results in higher vulnerability to injuries (Williams, 1998). *“Gymnasts who have maladaptive personality traits, such as high anxiety and negative mood, significant life stress, and low coping resources are most likely to become injured”* (Shapiro et al., 2020).

Hughes and Coakley identified the “sport ethic” which not only describes the culture of competitive sport but is also applicable to professional dance as one that encourages athletes to take physical risks to reach higher goals, make personal sacrifices for the show strive for distinction among other athletes, perform with pain and denying limits (Hughes et al., 1991).

Young gymnasts are often socialized in a way where crying or showcasing emotion, especially during an injury, are perceived as a weakness, which helps to accept pain as a part of the game (Hughes et al., 1991). These attitudes are often described as “no pain, no gain,” “pain is temporary, pride is forever,” and “whatever it takes” (Shapiro et al., 2020; Molnar, 2017). “Coaches may inadvertently (or purposely) foster this culture of risk-taking by ignoring or

making fun of gymnasts who report an injury, who take time off to recover from an injury, and/or by giving accolades to gymnasts who compete when hurt” (Shapiro et al., 2020).

Dancers easily face destructive instructions (Gibbons, 2004). “*Verbal aggressiveness is a destructive communication that involves attacking another person’s self-concept to intentionally hurt the receiver*” (Infante & Wigley, 1986). This may lead to negative relationship outcomes, and, if the regularity is constant against one person, it constitutes psychological abuse (Infante & Rancer, 1996). With enough stress, even the most resilient performer or athlete will show stress symptoms, which may manifest in psychological and/or physiologic disorders (i.e., anxiety, depression, posttraumatic stress disorder (PTSD), cardiovascular disease, metabolic disorders, autoimmune disorders) (Thomson, 2020).

In each individual, to varying degrees, a critical threshold is associated with the dose-response theory of trauma exposure (Wilson et al., 1989). In athletes and dancers, this dose response may further increase the risk of injury, especially if they develop dissociative coping strategies (disengage or detach) to avoid painful memories (Thomson, 2020).

The dose-response theory models a positive association between potentially traumatic lifetime events (PTEs) and negative mental health outcomes (Turner & Lloyd 1995). Research suggests that multiple PTE experience leads to a broader pattern of psychopathology compared to single experiences (Briere et al., 2016; Contractor et al., 2018; Diamond et al., 2010; Herman, 2012; Mollica et al., 1998; Stein et al., 2016; Turner & Lloyd, 1995); which is also called “Building block” cumulative effect (Schauer et al., 2003; Kolassa et al., 2010). Experiencing PTE may lead to perceived changes in the self, maladaptive coping strategies (Fetzner et al., 2014; DePrince et al., 2011), negative cognitive appraisals (Whiting and Bryant, 2007), and physiological changes (Campbell et al., 2007; Cicerone and Fraser, 1999) including neurological maldevelopment (Heim et al., 2008). During stressful situations, maladaptive dissociative coping strategies may blunt awareness of fatigue and pain, which may increase injury risk and compromise healing post-injury or post-orthopedic surgery (Vogel et al., 2019).

4. Qualitative research

4.1. Background

Classical ballet artists use one of the most complex combinations of motor skills, often under high pressure (Guss-West & Wulf, 2016). Working under pressure develops the ability to self-regulate, which, for well-being, is an important skill among both athletes and professional dancers (Balk & Englert, 2020). Although the rate of injuries is high among professional dancers (Jacobs et al., 2017), the body's ability to self-heal, including regeneration, may be impaired. The body's ability to self-heal can be defined as identifying an individual's current state and desired future state, and implementing measures that minimize the discrepancy between the two states during the recovery phase (Balk & Englert, 2020).

The interpersonal relationship has a crucial role in everyday life. Not only familiar but professional relationships can result in difficult situations, that people may succeed or fail to cope with. Interpersonal difficulties can be easier solved when the involved individuals are motivated (Erozkan, 2013). If a power differential exists between the participants, difficulties may arise and fewer opportunities are given to solve the appearing problem (Danner, 1990; Jo et al., 2018). In tutor-student, coach-athlete, or master-dancer relationship unequally powered roles can be found (Wong et al., 2016; Ibrahim et al., 2020), which raise the question of whether the subordinate role can cope with the interpersonal difficulties.

The body's ability to self-heal may be a slower process in a state of fatigue and negative mood (Baumeister et al., 2007), which may further impair the quality of self-healing (Balk & Englert, 2020). Among elite athletes, the negative mood is strongly associated with their coaching behavior (Buning & Thompson, 2015) as an external source of motivation, usually consisting of instructions and feedback (Price & Weiss, 2000). In the ballet room, verbal instruction is the dominant activity provided by teachers and coaches (Potrac et al., 2000; Hodges & Franks, 2002). Performing arts require continuous kinetic learning, which is heavily feedback-dependent, so verbal instructions seem to be key tools. (More & Franks, 1996). Verbal instruction and feedback have long been considered essential psychological and pedagogical competencies for coaches (Holding, 1965; Chow, 2013; Button et al., 2020). Small differences in the wording of instructions or feedback given by teachers can have a significant impact on the performance and effectiveness of motor skills (Guss-West & Wulf, 2016). For example, Goldman (2009) also suggests that the behavior of the majority of toxic leaders is driven by mental and emotional disturbances, while Ghaemi (2011) argues that toxic leaders are

fundamentally mentally ill leaders who can function more effectively in times of crisis. While Goldman (2009) argues that toxic leadership behavior should be understood in the context of organizational culture, toxic leadership can have serious consequences for both the organization and its employees. A toxic work environment, including toxic leadership and verbal harassment, has a strongly negative impact on an organization's performance (Anjum et al., 2018) and increases workplace stress (Wang et al., 2020). In the present research, we were interested in the professional dancers' lived experiences regarding their interpersonal relationship with their leaders, who could either be their teacher (as they called "master") or their director, choreographer, and the sources of stress that can affect regeneration.

4.2. Method

Semi-structured interviews were combined with a photo-elicitation qualitative interview model. Photo-elicitation is a method to use images for exploration, it gives voice and reaction to subjects (Harper, 2002). We have chosen this method based on the preconception that professional dancers might have difficulties with the pure verbal recall of their experiences (Starkes et al., 1987). For the analysis, we have used Interpretative Phenomenological Analysis (IPA), which is a recently developed and rapidly growing approach to qualitative inquiry (Smith et al., 2008). It is best known in the field of psychology. IPA is a phenomenological qualitative research approach committed to the examination of how people make sense of their major life experiences (Smith et al., 2008). IPA is dedicated to the detailed examination of a particular case, also called the idiographic method (Smith et al., 2008).

4.3. Procedure

Recruitment for the study started in January 2021. We have published the research proposal and put online advertisements on social media platforms and dance-specific social groups in Hungary. The inclusion criteria were that the participant had to have received professional dance education and they had to have at least three years of professional dance experience. We accepted classical ballet, modern and contemporary dancers, theatrical, and performing artists' applications. Exclusion criteria included being underaged (18 years), having less than three years of experience, and not being professionally trained dancers. We have also excluded those dancers who were under current psychotherapy. Out of 21 applicants, based on the inclusion and exclusion criteria at the pre-interviews, we selected 13 professional dancers. Each participant signed an informed consent form. The research was permitted by the Research Ethics Committee of the university. After the recruitment, dancers were asked to take pictures

of their techniques and activities that they applied in everyday life for recovery. We have not specified what this should focus on but asked to have at least 5 pictures that best describe how they recover. The dancers had two weeks to collect pictures before the interview was scheduled.

The interviews took place online via the ZOOM platform, where we recorded the conversations (mean time = 57 mins). The interviews were semi-structured. After the interviews transcripts were made based on the recordings, then analysis started. First, we read and re-read the interviews, then we took initial notes involving the analysis of the speech, language, and conceptual comments. After the descriptive notes, we created emergent themes. The emergent themes followed the interviews’ polarization, conceptualization, and contextualization where we made subsumptions and numerations. Each of the interviews was transcribed in written form. After each of the analyses, we summarized the results and matched the mutual themes.

4.4. Results

4.4.1. Result 1: Cross-sectional findings, Interpersonal Difficulties

Based on the interviews we have made three emergent themes: 1) Sub-ordinate the self to dance and the attending leader, 2) Constant superiority, 3) Pattern following and seven subcategories. The results are summarized in Table 5.

Table 5: Results 1: emergent themes and their subcategories

Emergent themes	1.	Sub-ordinate the self to dance and the attending leader	2.	Constant superiority	3.	Pattern following
Subcategories	1.1.	Suppression of physical and spiritual needs	2.1.	Highlighting substitutability	3.1.	Isolation
	1.2.	Fear of dropping out	2.2.	Constant tension		-
	1.3.	Difficulties with saying no	2.3.	Star cult		-

1.) Sub-ordinate the self to dance and the attending leader included the 1.1. total suppression of the physical and spiritual demands. *“There is no ideal dancer, I think there is one who is maximalist enough about himself to do everything he can to give his best. And this everything has no boundaries.”*

The interviewee suggested with this sentence that boundaries will result in lower quality in performance so to avoid it, dancers should always push themselves forward without any limiting agent left behind those factors that would alter the performance. These factors can be pain, tiredness, lower level of motivation, or mood lability.

Dancers felt that their physiological or psychological demands were less important compared to the goals they should reach in their daily training or on stage. Demands included nutritional, mental, and spiritual needs, relaxation and physical resting, and the suppression of their emotions. The dancers also clarified that they have a 1.2) general fear about dropping out, which is contextualized during their whole carrier, since in their training there were exams, two times a year, to decide who could stay in the education system. *“The first of these was, when I saw a smaller child in the locker room, a guy I know talking to his teddy bear while pinching his hand, which was bleeding and crying, talking to himself because he got average on the ballet exam.”* In this case, our interviewee was witnessing another student of the school talking to his teddy bear and pinching his hand while it was bleeding. Our interviewee correlated the situation with a year grade that students get after the ballet examination, which is a formal way of showing choreographed ballet training. He mentioned that these exams and the grades had a great impact on students, they were anxious about the exams and the feedback. These exam results sometimes meant dropping out of the program or a warning of a possible dropping out based on technical or body weight issues. All the participants in the study ensured that these exams were a real pressure.

During the interviews we have found that dancers have 1.3.) difficulties with saying ‘no’ regarding their professional life. *“The master and his word are sacred and only he is right and can only be what he says. This is the general concept of the school and actually the theater later too.”* *“The school raised in us that you are a good soldier, stay quiet and line up, do it.”* *“We did not dare to intervene or tell the master that: well... it's okay now to stop doing this.”* Many of the participants who had at least 7 years of working experience mentioned that they are “getting better” in this. They clarified that although the education made them accept whatever comes—even a role or a particular instruction to fulfill—as they were getting older, they realized how toxic this could be.

2.) Constant superiority has been established on strong hierarchal interpersonal relationships. The participants concluded that the attending leader should always be right and the dancers' role is to follow the instruction. Instructions are highly valuable to dancers and it seems that teachers are 2.1.) highlighting its importance in a matter of forced acceptance. *"Our ballet master told us: rejoice while we talk to you, even if you get negative criticism, because if it's no longer a problem it means they don't pay attention to you, they don't look at you."*

Although they felt respect for their earlier coaches and the present attending leaders, they described that there is a 2.2.) constant tension and anxiety, especially when the leader or coach is physically showing up. *"I'd rather put it this way, so these certain people go down the corridor and then we bend our hands, step back, and rigidly welcome them with that constant tension in our stomach."* The interviewee described that these situations were crude and fearful. Some said they felt an internal, not expressed aggression, some felt fear at the moment these teachers or leaders appeared. They have less confidence to talk about their thoughts, especially if it is against the given instructions.

Dancers experienced that during their educational careers, a 2.3.) "star cult" existed. "Star cult" was defined as such: the coach picks a person in the group, who is constantly motivated and encouraged by the teacher, based on subjective opinion, while the others are belittled and these roles changed over time. *"There was always someone who was just the best in the class. Once I could be too, but only for short because I got sick. At that time anything you did was perfect, You were the best but the others sucked and there was usually one who got everything."* Participants reported that even though they studied together for years, interpersonal relationships with their peers were labile. Some of the participants reported being victims of bullying from their peers, which was parallel to the time when they were not the "ones" picked to be the talent of the class.

3.) Pattern following has appeared in the context of their respective teaching and coaching experiences. Most of the participants have already tried teaching dance, where they used their own experiences to give feedback. The interviewees reported not using any scientific or accepted pedagogical model to give instructions or feedback, but the ones experienced during their career or education. Some of them even hear their own coach's voice when they see mistakes in their students. *"I am inspired by the school years, I hear my ex-ballet teacher's voice in me, how and what she said to show what I did wrong. These memories live in my head. I use this, I apply it."* Regarding the information flow there is a complete 3.1.) isolation in professional dance. Dancers described that during their educational period, they did not have

friends in non-dancer communities, they had a lack of time to visit programs other than those strictly related to their studies and some who were admitted to the dormitory during the study years severely decreased the time and connection with their parents and family members. They felt isolated.

4.4.2. Result 2: Longitudinal findings, Career Modalities

We found three emergent themes—Hierarchy, Uncertainty, and Perfectionism—, which are summarized in Table 6 with their subcategories.

Table 6: Result 2. Emergent themes and their subcategories

Emergent themes	1.	Hierarchy	2.	Uncertainty	3.	Perfectionism
Subcategories	1.1.	Showcasing power and constant superiority	2.1.	Lack of career model	3.1.	Constant exaggerated expectation
	1.2.	Total Submission	2.2.	Financial uncertainty	3.2.	No-pain, no-gain
	1.3.	-	2.3.	Unpredictable schedule	3.3.	-

1.) Hierarchy: “A dancer should always be humbled and respect the attending leader above in the hierarchy.” It appears to be a systemic expectation embedded into the curriculum either in professional training or working circumstances. Hierarchy was mentioned by the dancers as a negative factor of the professional dance community, which is highly prioritized and extremely important to fulfill. Hierarchy was linked to being humbled and respecting the attending leader or tutor. Within this emergent theme, we could separate subcategories: Showcasing power and constant inferiority, and total submission.

1.1.) Showcasing power and constant superiority was mentioned in several interviews, talking about how their ballet teacher created the image to be “The Master”. In the interviews, dancers highlighted, that their “master” was highly respected, and it is a common rule, that you never say anything against them. Dancers mentioned situations happening during their training such as, when a master enters the room, *“everyone shuts their mouth”*. Interviewees also highlighted, that during their education the appearance of the master was not only the point of being silent, but they started to feel fear and they felt to hide everything, such as their feelings, physical status, or family issues, over ballet. 1.2.) Total submission was set up as a second subcategory considering the dancers’ role in this highly hierarchic system. Dancers reported: *“No one cares what your needs are, if he says to do it once more, no matter what, you do it.”*

Those who tried to respectfully report their needs to the master were forcefully rejected, and no plea was accepted. *“If you riot, it gets even worse... And you know, we should be thankful to get attention because if we do not, then it means we are not counted anymore.”* Silent treatment is a commonly used technique against those dancers, who show a *“refusal attitude”* against the attending leaders’ words. Experienced but still on-stage working dancers described that *“opposing is just showing you are weak... and dance is not easy, if you cannot deal with, you should do something else.”*

The second emergent theme was 2.) uncertainty. During the interviews, we found that dancers felt uncertainty regarding their careers, professional life, and personal life. Life-work balance is an issue in professional dance. Interviewees regularly mentioned the discrepancy of the years and effort input into professional dance training and the possible ensured professional outcome and economic safety with regards to their careers. Uncertainty mainly focused on 2.1.) the lack of a career model. They have anxiety regarding the *“shortness of the dance career”* during which they should *“do the most you can, till you can.”*

The interviewees also clarified that 2.2.) financial uncertainty has also a great impact on their everyday life. A dancer described an exact situation when they were humiliated on the stage by their choreographer, because some of the dancers have previously asked the secretariats about the payment for their extra working hours, not included in their general contract. A dancer has also said. *“If I am not doing it, there are hundreds of other dancers taking my role immediately.”*

In the interviews we found, that dancers have an entirely 2.3.) unpredictable schedule, that usually changes day by day. An interviewee said, *“This is the most unbearable of the whole thing that we cannot even plan to do anything else outside the theater.”*

The third emergent theme was 3.) perfectionism. Dancers showed a high level of perfectionism regarding their professional work and bodies. They described 3.1.) a constant exaggerated expectation that is either represented by their attending leader and in the interviewees. These expectations are often over a limit: *“Dance is not healthy on this level.”* The participants also described that pushing themselves forward created new expectations and goals to fulfill for what they had a supportive common saying: *“You have to step out of your comfort zone”*. Some of the dancers felt that in case they are not working on themselves, they might not fulfill the requirements. *“I was never told directly to dance when I was injured, but I don’t know... deep in me I felt, that I have to do it no matter what.”*

We found that perfectionism involves the 3.2.) no pain, no gain theory. A dancer said, *“If it doesn’t hurt, it is not good enough”*. Although the participants highlighted that the no pain, no gain theory was already outdated, it has an everyday usage, and *“it is somehow true”*.

4.5. Discussion

During the interviews, it became clear that the dancers are facing high levels of stress from several sources. Based on the interviews, we created three emerging topics that we wanted to categorize as possible sources of stress levels for dancers. Hierarchy, uncertainty, and perfectionism were found to be the most common themes. Hierarchy and uncertainty appear to be interrelated, while several factors are present in both topics. Although these factors are different, they appear to increase the vulnerability of dancers. The high-level hierarchy developed in the early stages of training creates a rigorous atmosphere where dancers are not allowed to be honest and express themselves or express their physical or psychological needs. Masters and their students engage in one-way communication that is demanding but not supportive. The majority of participants also mentioned that *“this is the only way to achieve high goals in professional dance”*. Dancers experience verbal abuse (belittling, humiliation, shame), which is partly incorporated into their daily professional instructions and feedback mechanisms. We have noticed that dancers experience an aggressive tone daily (Infante & Wigley, 1986) from their coaches, and are conditioned to accept and even respect them, moreover, to be grateful for it. During their professional studies and working years, they experience the aggressive sound that is often present in the dance hall, in a professional environment.

According to the interviews, professional dancer instructions correlate with the definition of destructive voice: *“Voluntary disclosure of hurtful, critical, or derogatory remarks about the*

current state, aimed at challenging the status quo” (Maynes & Podsakoff, 2014, p. 91). As dancers work with a coach for months or even years, the regularity of aggressive messages can increase, leading to psychological abuse (Infante & Rancer, 1996). Because verbal instruction is a major source of feedback in professional dance (Guss-West & Wulf, 2016), quality and the assessed abusive role have a major impact on the lives of individuals (Ito et al., 2015). The general uncertainty puts the dancers in a vulnerable position as employees. The lack of a career model means that dancers’ employment as performers is limited and career opportunities are unclear. Interviewees did not mention any particular strategy, vision, or mission after years as an active dancer. As the number of theatrical years seems problematic for performers, this can increase the chances of becoming perfectionists as far as their bodies and dance techniques are concerned, which can further increase the level of vulnerability. While the dancers are working hard on their current careers, they are worried about their future. While dancers have high expectations of themselves, the external expectations of their leader and instructor are also significant. Pfeffer (1998) calls organizations that cause excessive stress to their members “toxic workplaces”.

Perfectionism can be associated with a toxic work environment as a kind of coping mechanism. While dancers are happy to perform to a high standard, there is a lack of a career path and a high degree of economic and organizational uncertainty, which can increase the level of perfectionism of dancers. The lack of safety, but the high demand for the leader, can be a stress-increasing factor for dancers, which is characteristic of a toxic work environment (Krumov, 2015). Toxic organizational culture contributes to discriminatory attitudes, low-quality working relationships, mutual mistrust, destructive conflicts, and emotionally manipulative lines of communication (Härtel, 2008), which was not revealed in the interviews, although some dancers mentioned that they had suffered with their peers during their years of training and described the emotionally based patterns of communication they had often experienced. A toxic workplace atmosphere means toxic driving, which also appears in this case. The quiet treatment and repression of individuality, while setting ambitious goals, suggest that participants have faced toxic leaders throughout their dance careers. Toxic leaders can quickly confuse others and inexplicably move people out of the “penitentiary”. (Wasylyshyn, 2012). According to Wasylyshyn, their psychological profile indicates that they are individuals with undiagnosed bipolar disorder, psychopathy, or other personality disorder, including narcissistic personality disorder and borderline personality disorder (Wasylyshyn, 2012).

Although it appears that participants are still operating in this toxic atmosphere, these are job conditions, especially the fact that their training begins in early childhood (at the age of 10), that certainly have a major impact on their mental health and well-being. According to the interviews, some of the participants felt traumatized during their training years, some denying that they had been harmed. Although later participants also mentioned personal stories of humiliation, interviewees were not traumatized, but rather emphasized that this was a “natural way to become a dancer”.

Based on these results, we judge that the dancers in the present study work in a toxic work and study environment that consists of the repression, humiliation, and humiliation of their individuality, which are common forms of abuse, including silent treatment and lack of employment security. Coupled with a high degree of uncertainty, which makes them more vulnerable to abuse. This finding correlates with other published articles evaluating toxic work environments where study participants may experience post-traumatic stress disorder (PTSD) as a possible outcome. Toxic leaders, like destructive leaders, demoralize employees with their behavior and negatively affect their mental and physical health. Many of their employees suffer from occupational stress and post-traumatic stress disorder (Leymann 1996; Olafsson & Johannsdottir, 2004).

5. Quantitative research

5.1. Research aims and hypothesis

In the qualitative study, we found that several factors influence professional dancers' well-being, mental status, regeneration, and stress level. We found that the educational and working environment is more toxic than supportive, where we assessed possible abusive acts embedded into professional instructions and pedagogical strategy. We considered assessing whether certain types of abuses (psychological and physical) are prevalent within the professional dancers' community in Hungary. During the qualitative research, we could conclude that regeneration in this population is impaired; dancers reported previous and current injuries. This result made us interested in quantifying and dividing the injuries and pathological musculoskeletal conditions; moreover, to assess complaints and symptoms regarding their body. Although the interviews had no diagnostic purposes, we found signs of possible psychopathologies appearing within this community. For this purpose, we hypothesize that dancers may be affected by dissociative symptoms, reduced well-being, and PTSD. Although we have found several victims of different kinds of abusive acts and toxic environments, we mostly found highly functioning individuals. Therefore, we are interested in resilience within this study population. For further assessment, we have established the quantitative studies with the following goals:

- Assess and quantify the level of stress dancers report,
- Assess and quantify whether pathological dissociation appears among professional dancers,
- Assess and quantify the injuries, with regards to the sites and rate,
- Quantify the abusive acts against professional dancers,
- Investigate the possible relationship between certain stress factors and health outcomes.

5.2. Power calculation

The estimated sample size by using the sample size calculator (Lenth, 2006) is 162, the population number is 280 when α equals 0.05 for the two-sided test, β (power) = 0.8. According to our preliminary data from the pilot study, recruitment is possible from this population, where the data will be used to evaluate the stress level, the abusive experiences, the dissociation score, and their relations.

$$n = \left(\frac{\sigma \left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta} \right)}{\mu_0 - \mu_1} \right)^2$$

Figure 8: General form of sample size calculation
(n = sample size, σ = standard deviation, $Z_{1-\alpha}$ = related to type I error, $Z_{1-\beta}$ = related to type II error, μ = mean under the null and alternative hypothesis.)

5.3. Material and method

5.3.1. Study population

In this study, we collected 191 Hungarian professional dancers to fill out the questionnaire. After the first review of the data, we excluded those who did not fill out at least 50% of the questionnaire; 16 answers were given by male dancers since the male gender representation was only 9%. In total, we had 168 answers (n = 168). Within the study population, we found that the mean age was 32 ($\mu = 32.43$ SD=10.89), 24.8% were classical ballet dancers, 51.2% were modern dancers, 17.8% were theatrical dancers, and 5.9% were folk dancers. The participants had more than 15 years of professional experience within the dance industry ($\mu = 15.52$ years, SD = 10.9). The dancers who filled out our questionnaire were 91.7% professionally educated, where 74.4% had university or college degrees in professional dance and 16.6% dance specific high school diplomas.

5.3.2. Statistical analysis

For the statistical analysis, we used SPSS 28.0.0. Distribution was tested with Kolmogorov-Smirnov Test and graphical methods. We used descriptive studies to assess mean (μ), standard deviation (SD), range, and median (M) for some of the variables, as well as frequency analysis to summarize the data such as injuries/pathological musculoskeletal conditions and abuses. For the relationship analysis, we used regression methods, curve estimation, linear and logistic regression, and Pearson and Spearman's correlation depending on the type and distribution of the variables. Pearson's correlation coefficient is the test statistic that measures the statistical relationship, or association, between two continuous variables. The assumption indicates the independence of cases, linear relationship, and homoscedasticity. Coefficient values can range from +1 to -1, where +1 indicates a perfect positive relationship, -1 indicates a perfect negative relationship, and 0 indicates the nonexistence of a relationship (Rosner, 2015, p. 509–520).

Spearman rank-order correlation test is used for either ordinal variables or for continuous data that has failed the assumptions necessary for conducting Pearson's product-moment correlation. We used relative risk and odds ratio to assess the relationship between certain variables. For this procedure, we created two-by-two tables of the tested variables. The relative risk can be expressed as the ratio of the probability of 'disease' among exposed subjects (p_1) divided by the probability of 'disease' among unexposed subjects (p_2) and the disease-odds ratio is the odds in favor of 'disease' for the exposed group divided by the odds in favor of 'disease' for the unexposed group (Rosner, 2015, p. 668). For time to event variables, we used the Kaplan-Meier Survival analysis, Hazard Curves in the case of univariate models, and the Cox-regression in multivariate models to assess survival or hazard outcomes. Statistical significance was set to $\alpha < 0.05$, and the confidence interval to 95%.

5.3.3. Questionnaires

According to the study aims, we have collected six validated psychometric questionnaires. *Dissociative Experience Scale II* (Bernstein & Putnam, 1986): The 28-item self-administered questionnaire measures the frequency of dissociative symptoms in everyday life. Respondents rate the frequency of each experience on a ten-point scale (ranging from 0% to 100%) which is often used on both healthy and clinical samples. Carlson and Putnam (1993) distinguished between DES-II 3 factors: amnesic symptoms, absorption/imaginary involvement, and depersonalization/derealization symptoms. The validity and reliability indicators of the scale proved to be very good, the internal reliability of the scale was found to be good (Cronbach's $\alpha = 0.88$) (Simor et al., 2011). We retested this questionnaire where Cronbach's α was: 0.971 and Kaiser-Meyer-Olkin Sampling Adequacy test showed: 0.900.

Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) (Kellmann et al., 2001): is a questionnaire reported to identify the extent to which athletes are physically or mentally stressed and their current capabilities towards recovery (Kellmann & Kallus 2001). The RESTQ-Sport was developed through continuous bio-psychological research in the area of stress for the General Scale, and the Sport Scale was comprised of items observed to coincide with stress or recovery states in athletes (Kellmann & Kallus, 2001). RESTQ-Sport consists of 12 General Stress and Recovery scales along with seven Sport-specific Stress and Recovery scales (Kellmann & Kallus, 2001). The General Stress component includes three scales, which measure general stress, emotional stress, and social stress along with their consequences. Three General Stress Scales are concerned with performance aspects (scales measuring

conflicts/pressure, fatigue, and lack of energy). The scale “physical complaints”, measures the physical aspects of stress. Cronbach- α values for each of the 19 separate subscales, comprised of hypothesized items, ranging from .72 to .93 (Kellmann & Kallus, 2001). Test-retest reliability of the individual Subscales achieving correlational values above 0.79 (Kellmann & Kallus, 2000; Kellmann & Kallus, 2001). The Hungarian translation and validation were made by Tóth et al. (2019).

Perceived Stress Scale (PSS) (Cohen & Williamson, 1988) PSSs an abbreviated but researchable 5-point Likert scale of 4 items from the original 14-item questionnaire (Cohen & Williamson, 1988). It asks about those thoughts and feelings which characterize the person's stress perception: “How much stress do you experience?”, “How unpredictable, unaffected, overwhelmed their everyday life is?” (Stauder et al., 2006). The three versions of the questionnaire (PSS14, PSS10, PSS4) are highly correlated ($r = 0.99$ and 0.93), all three have very good internal reliability (Cronbach's α 0.88; 0.85; 0.79), and the reliability of the test-retest is also excellent ($r = 0.90$) (Stauder et al., 2006).

The Mental Health Test (Vargha et al., 2019): The basic concept of the test is to obtain a comprehensive picture of the subject's mental health concerning the five pillars using a short questionnaire of no more than 20 items (Oláh et al., 2018; Vargha et al., 2019). It has two subscales we analyzed and the results are used in our study: well-being and resilience.

Self Estimated Functional Inability because of Pain Questionnaire (SEFIP) (Ramel et al., 1999) The basic structure of the SEFIP consists of 14 items representing body parts: neck, shoulders, elbows, wrists/hands, upper back, lower back, hips, thighs (front), thighs (back), knees, legs (front), calves, ankles, and feet. Points on the SEFIP scale are calculated as follows: “I am entirely free of pain” = 0 points; “I have slight pain but it is no problem” = 1 point; “I have quite a bit of pain but I can dance if I am careful” = 2 points; “I have a lot of pain and have to avoid certain movements” = 3 points; “I have great difficulty and cannot take part in the production” = 4 points. Values of reliability ($\kappa \geq 0.40$, intraclass correlation coefficient = 0.91), internal consistency (Cronbach's $\alpha \geq 0.81$), and correlations ($r_s \geq -0.376$) of the total SEFIP-sport score with the numerical rating scale (Jodimar et al., 2021).

Body Responsiveness Questionnaire (BRW) (Daubenmier, 2005; Tihanyi et al., 2016): Body responsiveness is assessed using a 7-item questionnaire that “assesses the tendency to integrate body sensations into conscious awareness to guide decision making and behavior and not suppress or react impulsively to them” (Daubenmier, 2005). There are two subscales: The Importance of Interoceptive Awareness subscale (I-subscale) assesses the importance of using

interoceptive information to regulate behavior and self-awareness (items include “*I need to know how my body is feeling throughout the day*”, “*I am confident that my body will let me know what is good for me*”) and the Perceived Disconnection subscale (PD-subscale) measures the extent of perceived disconnection between psychological and bodily states, including suppressing and reacting impulsively to them (items include “*My mind and my body often want to do different things*”, “*I suppress my bodily feelings and sensations*”, “*My bodily desires lead me to do things that I end up regretting*”). Cronbach α 0.82 and 0.83 for I-subscale, 0.72 and 0.63 for PD-subscale respectively (Tihanyi et al., 2016).

Abusive Experience Scale at Professional Dance (AECPD) Over the validated questionnaires, we used demographic and specific abuse reporting questions. The questions were carefully created by the Ph.D. candidate based on the interviews and the preliminary data and reviewed by the supervisor Dr. Boros. Regarding the abusive experiences, we specifically asked about those that showed up in the preliminary study, such as (1) physical abuse in the form of object throwing in the ballet room or rehearsal; (2) the use of an aggressive voice, i.e. shouting at dancers or verbally forcing them to do something; (3) the experience of silent treatment in the form of ballet coaches voluntarily ignoring dancers for pedagogical reasons; (4) body shaming in the form of a verbal accusation; (5) belittling, i.e. being given mocked names by coaches, experiencing shameful words or contemptuous speaking. In every case, dancers had to choose between “Yes, I experienced it” or “No, I didn’t experience it.” We created only two options to decrease the possibility of bias. According to our knowledge, there is no available validated test focusing on the assessment of abusive experiences in professional dance, especially not in Hungarian. We tested its reliability in this study, where the Cronbach’s alpha showed a value of 0.778, Kaiser-Meyer-Olkin Sampling Adequacy showed: 0.701.

The questions were Hungarian adaptations that were implanted into an online questionnaire platform (Qualtricks), where we collected the data anonymously. The study was approved and supervised by the IRB at ELTE PPK with the presence of the Research Ethic Review Board (Approval number: 2021/419).

5.4. Results

5.4.1. Chronic conditions

5.4.1.1. Descriptive results

78.6% of the 168 participants suffered from pathological musculoskeletal alteration during their careers. The most frequently found chronic conditions were tendinopathies (22.6%) and chronic pain (20.2%), but chronic inflammation (17.9%) and spinal discus hernias (11.2%) were also represented. The frequency and types of abuses are implanted in a table (Table 5) below. We found that aggressive voice (79.9%) and belittling (68.6%) were highly represented among the answers, while silent treatment (55.6%) and body shaming (45%) also scored high. Physical abuse was reported by half of the study population (52.1%), where many of the dancers experienced painful, hurting, and inappropriate touch (this study is not investigating the sexual intentions) as an instruction given during the dance class.

Table 7: Frequency of abuse among dancers (n = 168)

Abuse frequency			
	Mean Frequency	Subscale	
Aggressive voice	79.9%	Shouting at him/her	78.1%
		Aggressive voice	81.7%
Silent treatment	55.6%	-	
Body shaming	45%	-	
Belittling	68.6%	To speak contemptuously	67.5%
		Mock nickname given	33.1%
		Ashamed	55.6%
Physical abuse	52.1%	An object thrown	37.9%
		instructive touch, that was painful	52.1%

The Dissociative Experience Scale (DES) score mean was ($\mu = 26.82$). 56.90% scored above 20 points on the scale and 21.6% scored for Post-Traumatic Stress Disease (PTSD) subscale (26–41 points). Under 20 points in the low-dissociation group, the Borderline subscale was represented by 14.4% (18–20 points). On the other end of the scale, multiple personality disorder was found in 7.2% (41–57 points). The dissociation disorder score was reached by 9.6%

(30–38 points). Although 72.6% of the population had high well-being scores, 19.04% experienced a very high level of general stress and 50.9% reported some level of sleep deprivation and 6.58% had extremely bad sleep quality.

5.4.1.2. Relationship analysis

The regression analysis has shown relationship between DES scores and chronic inflammation ($p = 0.02$; $r^2 = 0.03$; $\beta = 7.413$), chronic pain ($p = 0.028$; $r^2 = 0.3$; $\beta = 6.890$) and tendinopathy ($p = 0.04$, $r^2 = 0.25$; $\beta = 1.191$). Certain types of abuse were also investigated, where we found a relationship between chronic pain and physical assault ($p < 0.001$; $r^2 = 0.144$; $\beta = 0.077$), belittling ($p = 0.042$; $r^2 = 0.45$; $\beta = 0.008$), aggressive voice ($p = 0.031$; $r^2 = 0.3$; $\beta = 1.095$), and silent treatment ($p < 0.001$, $r^2 = 0.77$; $\beta = 1.261$). The years spent in the dance profession correlated with chronic musculoskeletal pathologies positively but not significantly. We found a negative correlation between the dissociative experience scale and resilience ($z = -0.188$ $p = 0.019$).

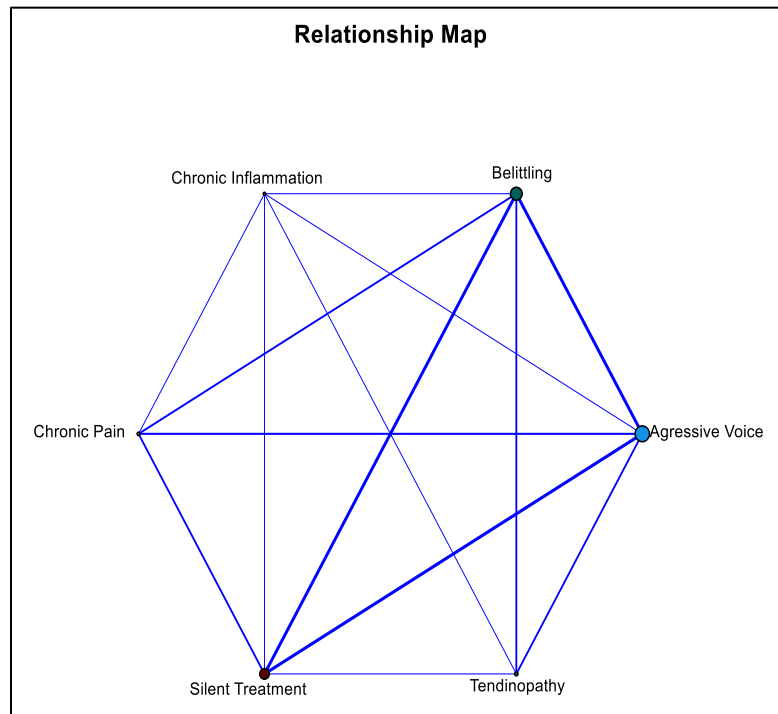


Figure 10: Relationship between abuses and reported chronic conditions

In this figure, we show the relationship between the abuse types and chronic pathological conditions, where the thickness of the line represents the strength of the relationship and the nodes represent the frequency of the variable compared to each other.

5.4.1.3. Risk estimation

The relative risk (RR) of silent treatment reported group suffering from chronic pain is 1.617 ($CI = 1.312-1.994$), while the non-silent treated individual suffering from chronic pain is 0.272 ($CI = 0.107-0.695$). The Odds ratio (OR) is 5.939.

At the relation of physical abuse and chronic pain the RR = 1.972 ($CI = 1.604-2.425$) while the non-abused group RR = 0.119 ($CI = 0.031-0.461$), OR is 16.552. Belittling and chronic pain RR = 1.243 ($CI = 1.086-1.423$) while not belittled dancers have RR = 0.254 ($CI = 0.064-1.008$) to suffer from chronic pain, here the odds ratio is 4.891. Lastly, we calculated the relative risk for body shaming and chronic pain where RR = 1.213 ($CI = 1.022-1.440$) and OR = 2.705. We have summarized the results in the table below.

Table 8: Relative risk and Odds ratio of the conditions and abuses (n = 168)

	Chronic Pain		
	Relative Risk	Confident Interval	Odds ratio
Silent Treatment	1.617	1.312-1.994	5.939
Physical Abuse	1.972	1.604-2.425	16.552
Belittling	1.243	1.086-1.423	4.891
Body Shaming	1.213	1.022-1.440	2.705
	Tendinopathy		
Silent Treatment	1.002	0.744-1.349	1.004
Physical Abuse	1.229	0.925-1.633	1.688
Belittling	1.279	1.083-1.510	3.512
Body Shaming	1.043	0.851-1.279	1.193
	Chronic Inflammation		
Silent Treatment	1.111	0.810-1.524	1.333
Physical Abuse	1.204	0.872-1.661	1.611
Belittling	1.152	0.936-1.419	1.915
Body Shaming	0.995	0.774-1.279	0.980

5.4.1.4. Survival analysis

With the Kaplan-Meier Survival Analysis, we investigated to possible outcomes of certain types of abuse and the formation of chronic pathological conditions on a time scale spending in professional dance.

Table 9: Kaplan-Meier Survival and Cox Proportional-Hazard Regression time-dependent (n = 168)

Kaplan-Meier Univariate Analysis			
Condition	Covariate	Estimation	Confidence Interval
Chronic Pain	Aggressive voice	14.125	10.9-17.3
	Physical Abuse	16.556	11.6-21.5
	Belittling	13.615	9.7-17.6
	Body Shaming	13.857	10.2-17.6
Tendinopathy	Aggressive voice	16.00	13.2-18.8
	Physical abuse	15.2	10.7-19.8
	Belittling	16.125	13.1-19.1
	Body shaming	16.071	12.7-19.4
Chronic inflammation	Aggressive voice	14.455	11.1-17.9
	Physical abuse	14.143	9.6-18.7
	Belittling	15.400	11.9-18.9
	Body shaming	16.333	12.9-19.7
Cox Regression Multivariate Analysis			
Condition	Chi-square	Significance	
Chronic pain	8.873	$p < 0.001$	
Tendinopathy	7.973	$p=0.001$	
Chronic inflammation	3.142	$p=0.172$	

5.4.2. Acute conditions

5.4.2.1. Descriptive results

Among the acute pathological conditions, we found that ligament rupture (39.3%) was the most abundant while bone fracture (17.9%) was also highly prevalent among professional dancers. Stress fractures (5%) were the least reported in this study.

Analyzing the perceived stress scale appeared that dancers are experiencing high levels of stress ($\mu = 12.58$ points $SD = 3.78$, where the total score is 20 points) where 92.4% of the study population scored above 10 points (see: Figure 11).

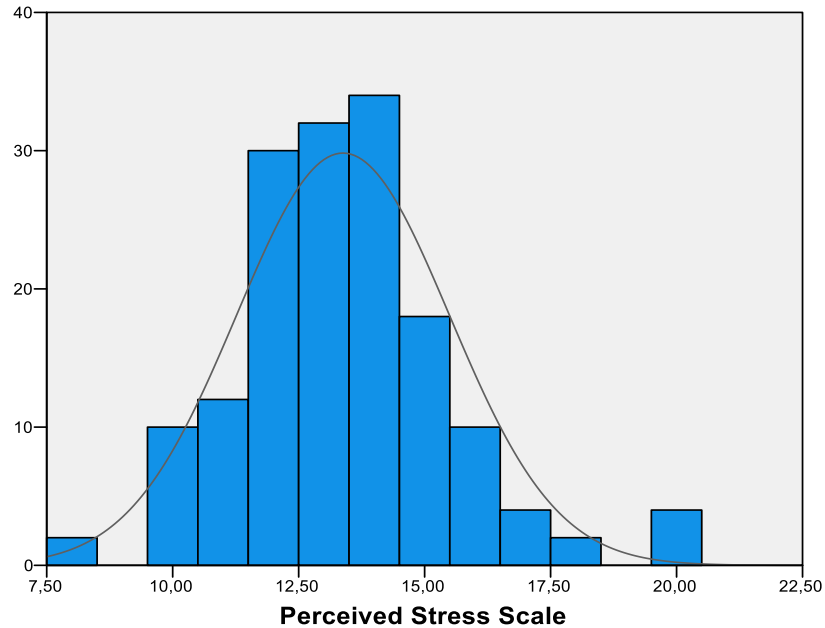


Figure 11: Histogram of Perceived Stress Scale distribution among respondents (n = 168)

Out of *The Mental Health Test*, we found that 22.5% of the study population reported a high well-being level, and altogether 72.6% can be considered to belong to a good mental state (above the 50% of the certain point-scale). The same questionnaire was used to evaluate the level of resilience, where we found that 12.2% reached the highest score and almost half of the population, 48.9%, belongs to resilient individuals.

The Self Estimated Functional Inability because of Pain questionnaire showed that less than 5 percent ($\mu = 4.57\%$) perceives currently functional limiting pain (“I have great difficulty and cannot take part in the production”) at different sites of their body, almost 10 percent ($\mu = 9.58$) reported currently experiencing severe pain with which the dancer can still dance (“I have a lot of pain and have to avoid certain movements”) and 21.4% scored some pain at certain sites of their body which does not limit the function (“I have quite a bit of pain but I can dance if I am careful”). 64.45% of the dancers reported no current pain at any sites. The top reported sites of pain were: The neck (23.7%), shoulder (19%), lower back (26.1%), knee (15.5%), and ankle (10.7%).

The *Body Responsiveness Questionnaire* showed a Perceived Disconnection (PD) score of 1–7, a mean of 2.71, and the Importance of Interoceptive Awareness (I) subscale showed 1–7 points with a mean of 5.53.

5.4.2.2. Relationship analysis

Years spent in professional dance correlated significantly with the incidence of ligament rupture ($r_s = 0.229$, $p = 0.003$) and bone fractures ($r_s = 0.219$, $p = 0.004$). These results were also implanted into a Kaplan Meier Curve (see below). We analyzed the relationship between acute stress and current symptoms of pain. We found that perceived stress (PSS) has a positive relationship with lower back ($r^2 = 0.41$, $p = 0.012$) and leg pain ($r^2 = 0.112$, $p < 0.001$), nevertheless with ankle ($r^2 = 0.021$, $p = 0.057$) and foot pain ($r^2 = 0.02$, $p = 0.059$) that we considered not significant although their p-value was not far from 95%. Other sites of reported pain (elbow, wrist, shoulder, etc.) did not show any relationship with PSS scores.

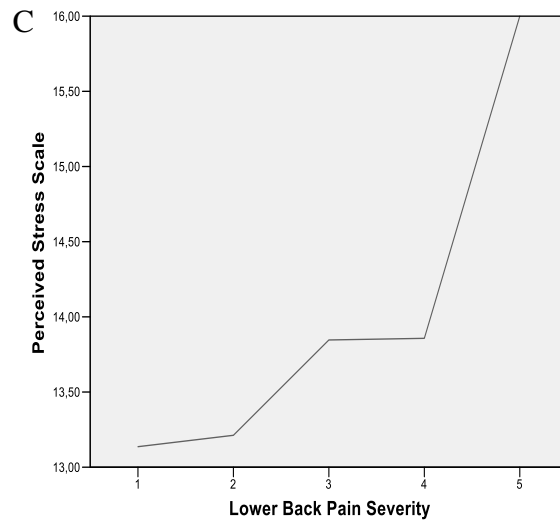
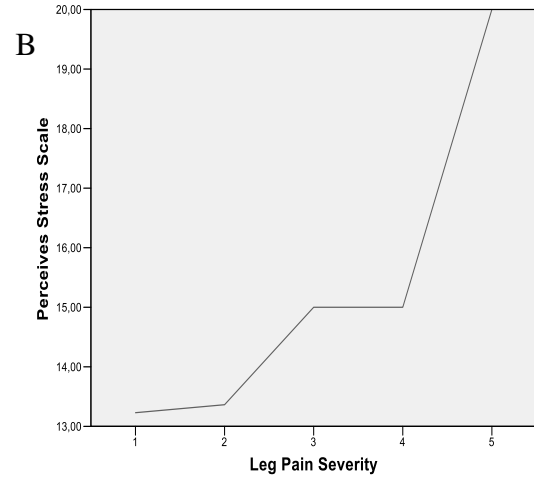
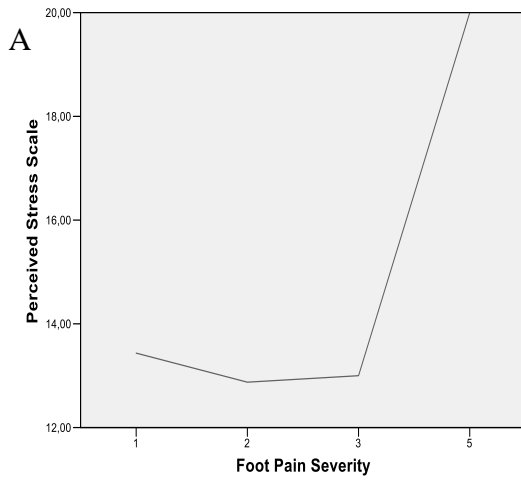


Figure 12: Perceived Stress Scale and Pain Severity graphs. A) Represents the PSS score and the Foot Pain Severity B) the PSS score and the Leg Pain severity and C) the PSS score and the Lower Back pain severity

5.4.2.3. Survival analysis

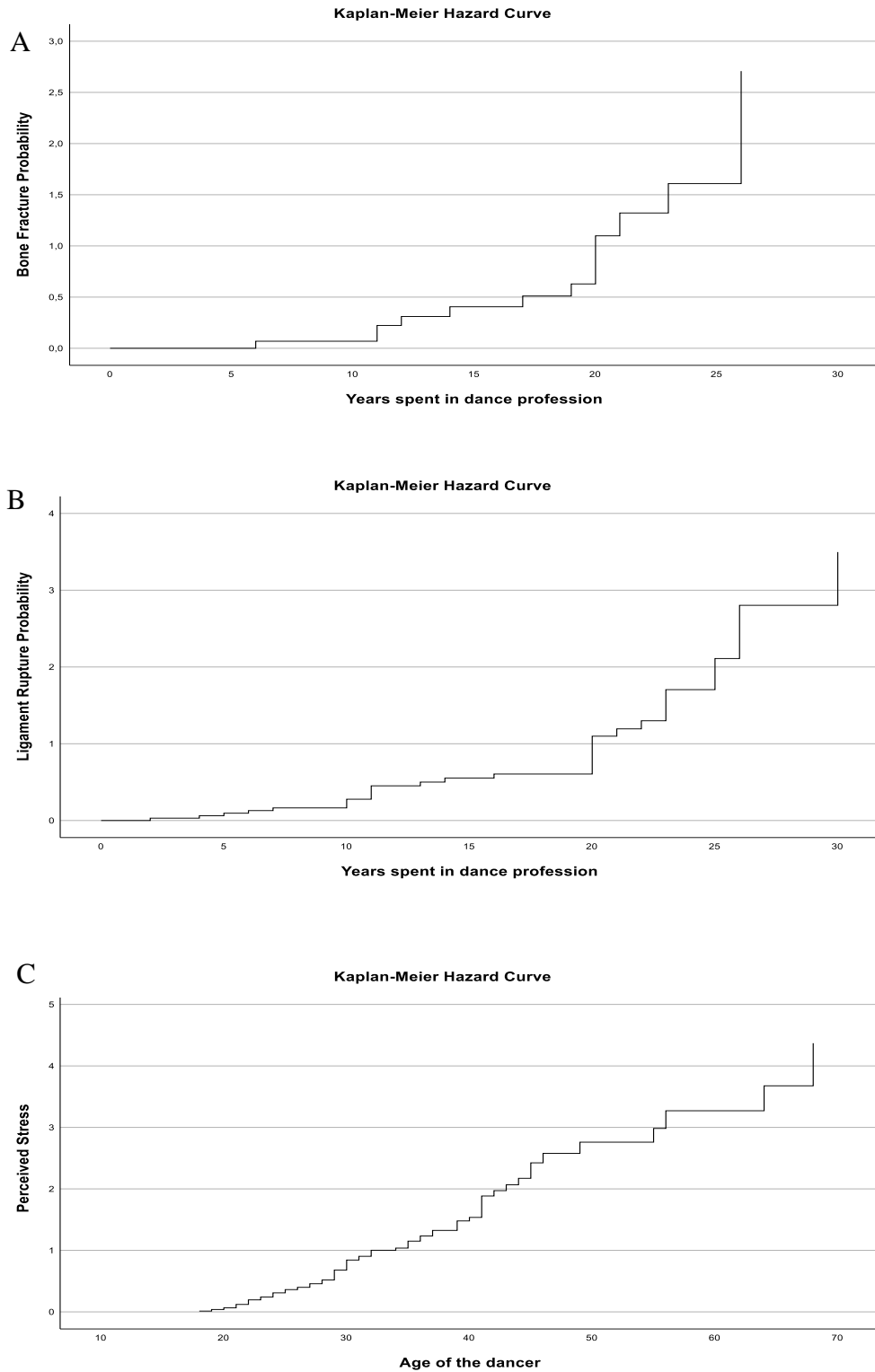


Figure 13: Kaplan-Meier Hazard Curve A) Years spent in the dance profession as a working dancer plotted with Bone Fracture Probability B) Yours spent in the dance profession plotted on a hazard curve with Ligament Rupture Probability C) Age of the dancer and Perceived Stress

5.5. Discussion

In this research, we aimed to assess the level of stress dancers experience, evaluate the degree of dissociation, quantify the pathological musculoskeletal conditions, with regards to their sites and rate, investigate the abusive acts against professional dancers, and evaluate the possible relationship between the certain stress factors and the health outcomes. Our main goal was to raise attention to an understudied scientific area which is emotional abuse in professional dance and its relationship with psychological and physical conditions. The novel concept that helped us design our study was the Stress and Injury Model (Williams & Andersen, 1998), which describes that stress is a risk of injuries among athletes.

The prevalence of general pathological musculoskeletal conditions among professional dancers was slightly higher (78.6%) than what was found in previous investigations, where global musculoskeletal conditions at all skill levels reached 47.1% to 69% (Jacobs et al., 2017; Bronner et al., 2018). Although their results did not mention the ratio between chronic and acute conditions, in other studies researchers collected found 42.1% to 77% injured among ballet students aged 9 and 20 years. These dancers reported being injured at least once during their training, which correlates with our results (Gamboa et al., 2008; Laenderson et al., 2011; Ekerger et al., 2014), too. The ligament and tendon pathology frequencies are similar to the literature data (Ekerger et al., 2014; Emery et al., 2006; Gamboa et al., 2008; Yin et al., 2016). Although we have not found data about chronic pain and chronic inflammation reported specifically on professional dancers in scientific research, our data show a high prevalence (11.2%–22.6%) among them.

Both the musculoskeletal condition rate and the reported abuse frequency are very high among the dancers participating in our study. Within this group, psychological abuse represented the highest rate ($\mu = 62.3\%$), although physical abuse (causing pain and throwing objects) was experienced by every other dancer ($\mu = 52.1\%$). These results correlate with our qualitative and preliminary studies, where we hypothesized that most of the dancers experience some kind of harassment, and the reported abuses are not an individual experience, but rather a systemic problem within the dance community. Among the psychological abuses, we found body shaming the least abundant (still almost every second dancer reported in the questionnaire), while aggressive voice and belittling are highly prevalent (7 out of 10 dancers experience it). To evaluate physical abuse, we emphasize that these cases are not considered the general

definition of physical abuse (National Clearinghouse on Child Abuse and Neglect, 2003), where beating and severe injuries may occur, but rather to cause transient, physical, mild to moderate pain to increase performance or quality of movement serving as an additional tool of verbal instructions. In the subscale, we asked about a common habitual act in the dance room, which is throwing objects, which is also considered a pedagogical strategy to strengthen the weight of the teacher's words. We have not found a statistically significant relationship between the years spent in dance and the abuses. This phenomenon is considered to be a reason for either 1) the prevalence of the abuse not being diffused during the whole career path but temporalized between a certain period, or 2) the resilience increasing and the repeated diffused abuses not being reported constantly. The earlier concept correlates with our previous qualitative results, where individuals have mentioned that the abuses they suffered most often happened in their educational or early career years.

Dancers scored high on the dissociative scale. More than half of the study population (56.9%) is considered to belong to the high dissociation group (above 20 points), and almost a quarter of the dancers (21.6%) belonged to the PTSD subscale group (26–41 points). This result can be compared with other data of this study, where we found that $\frac{3}{4}$ of the study population (72.6%) had good mental health and almost half of the population (48.9%) scored higher than their peers within the resilience subscale. Although the general mental health was high, 19% of the dancers reported a very high general level of stress, and this group can be associated with the PTSD group.

The DES score has a statistically significant relationship with chronic pathological musculoskeletal conditions such as chronic pain, inflammation, and tendinopathy. Although the results are significant, r^2 shows that only 3% of the chronic pathological conditions are completely explained by the DES score. This result is similar to the abusive experiences, (where silent treatment seems to have the highest r^2 value with 7%) so we conclude that abuses truly have a significant effect on the chronic musculoskeletal pathologies, but do not fully explain the conditions' existence. Regarding the three highest reported chronic conditions, the strongest correlation appears to be between abuse and chronic pain. As the literature suggests, these conditions have multifactorial etiology roles (Williams, 1998; Shapiro et al., 2020; Thomson et al., 2020); we summarize that psychological and physical abuse is currently appearing as one of the factors. Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (Merskey et al., 1994, p. 210), although it is necessary to distinguish between pain and nociception because there is a lack of absolute correspondence

between pain and tissue damage (Chapman & Nakamura, 1999; Craig, 2003; Eccleston & Crombez, 1999). Findings suggest that there is a possibility that an experience of pain can originate exclusively within a subject's brain or mind rather than being necessarily dependent on the pathology of peripheral tissue (Derbyshire et al., 2004). Pain is closely related to consciousness and there is also evidence that pain experiences may be modulated by cognition (Coghill et al., 1999; Eccleston & Crombez, 1999; Tiengo, 2003; Villemure & Bushnell, 2002). Furthermore, it is commonly associated with anxiety disorders (Asmundson et al., 2002; Van Loey et al., 2003) and PTSD (Asmundson et al., 2002; Sharp & Harvey, 2001). Patients with chronic pelvic pain were significantly more likely to use dissociation as a coping mechanism and significantly more likely to have experienced severe childhood sexual abuse (Badura et al., 1997; Walker et al., 1992). Our study showed a significant correlation between chronic pain and dissociation, which is similar to the results found in the literature (Fishbain et al., 2001; Frances & Spiegel, 1987; Livengood et al., 1994; McFadden & Woitalla, 1993; McFadden, 1992).

Psychological and physical abuse seems to be not only an etiological factor, but an undeniable risk to suffer from chronic pain, chronic inflammation, or tendinopathy. Risk estimation and odds ratio show that chronic pain has the highest risk to form in a population where the individuals are exposed to certain abuses in which physical abuse (causing pain) has the highest influencing factor of the exposures.

The survival analysis has shown that dancers have a high probability to suffer from chronic pain, inflammation, or tendinopathy if they spend 13 to 16 years continuously in the toxic dance industry, experiencing psychological and physical abuse. As Kaplan-Meier is a univariate analysis, we performed a Cox regression where time-dependent variable analysis was done to see the difference between uni-, and multivariate abuse experiences since dancers are not exclusively experiencing a type of abuse, but rather several of them at the same time. We found that the survival time drastically changes to half in the multivariate model, which means that the more types of abuse the dancer experiences, the earlier the probability to have chronic musculoskeletal pathologies arises. These calculations are estimations based on our study results, which cannot be extended to a general dancer population. Chronic inflammation shows the earliest outcome probability of the multivariable model. Trauma exposure resulting in chronic inflammation has several literature results. There are pro-inflammatory factors increased in the case of PTSD: C-reactive Protein which not only elevates as a result (Spitzer et al., 2010; Miller et al., 2001) but is suggested to be used as an indicator factor of PTSD (Michopoulos et al., 2014), Interleukin-6 (Maes et al., 1999; Devoto et al., 2017), IL-1 β (Fukata et al., 1989; Spivak

et al., 1997) TNF- α (Kim et al., 2020), IFN- γ (Woods et al., 2005; Groer et al., 2006). Chronic inflammation and tendinopathy are often examined associations. A study found that tissue and cells derived from tendinopathic and ruptured Achilles tendons show evidence of chronic (non-resolving) inflammation (Dakin et al., 2018). As we have plotted on the relationship map, we can assess that not only are certain abuses in a relationship with the chronic conditions, but chronic conditions are also in a relationship with each other, which correlates with their pathophysiology; we could also see that certain types of abuses are also in a relationship with each other, suggesting our earlier hypotheses to accept that dancers experience mixed types of abuses.

Within the acute conditions, we found that ligament rupture was the most abundant injury among our study population. This entirely correlates with the results found in the literature (Lindsay et al., 2017; Gamboa et al., 2008). Ligament rupture correlates with the time spent in professional dance with 23% explaining its existence. That is a much higher correlation than any of our stress-related factors produced. The Kaplan-Meier Hazard curve shows the positive correlation between the probability of bone fracture and ligament rupture with the years spent in dance. The Perceived Stress Scale gave us an extremely high stress level, which fits our preliminary and qualitative study results. We must consider that the PSS score is an acute stress perception report scale and it was filled out during the COVID pandemic. The pandemic has not biased the chronic stress and traumatic experiences scales, although the acute stress factors must have been influenced by the current situation. As the pandemic created a global crisis, dancers may have experienced a higher level of uncertainty regarding their economic and career status; this was already found a possible risk factor regarding their vulnerability to certain abusive acts. As it is a possible bias, we have not matched the results of perceived stress data to abusive experiences and chronic conditions, we rather established an acute status check protocol. Although perceived stress may be influenced by the pandemic circumstances, we found a positive correlation with the age of the dancer plotted on a hazard curve (Figure 12).

According to the pain questionnaire, more than half of the population (64.45) was free from any current pain symptoms, which we also considered to be confounding due to the global pandemic. Dancers during this time had fewer working hours and less physical activity, which provided two possible interpretations: 1) The reported current pain symptoms were remaining from earlier injuries, or 2) there is a correlation between stress and pain symptoms. Although our questionnaire did not investigate the first possible interpretation, our data research showed a significantly positive relationship between lower back and leg pain with PSS, while ankle and

foot pain were also related to PSS, but with a significance above 5%. The relationship was not strong, since it varied between 4% and 11% to be fully explained by the exposure, the plotted graph shows, the perceived stress relation with the pain severity. Lower back pain was associated with the existence of a neural mechanism where the specific modulation of brain activity enables manipulation of affective and sensory dimensions of the pain experience (Coghill et al., 2003; Croft, 2000; Derbyshire et al., 1997, 2002; Gracely et al., 2002; Rainville et al., 1997). Abnormal activation within the pain network (Gracely et al., 2002) shows a close relationship between pain and detecting cognitive conflict in the anterior cingulum that implicates the interconnection of stress (Shackman et al., 2011).

Other researchers found a relationship between lower back pain and stress levels (Choobineh et al., 2021; Faymonville et al., 2003). Electromyography results indicate that with chronic back pain, the paravertebral musculature shows abnormal muscular reactivity only when discussing personally relevant stress (Flor et al., 1985). Moreover, some results indicate that mindfulness techniques can relieve lower back pain (Anheyer et al., 2017).

6. Animal Model

6.1. Introduction

Earlier we found that dancers experience abuse during their professional careers which we identified as a toxic environment. A toxic environment may contribute to their high general stress level, which may lead to certain musculoskeletal alterations. We found that abuse may act as a risk factor for chronic pain, tendinopathy, and chronic inflammation. Since not only chronic musculoskeletal conditions had a high prevalence, but acute ligament ruptures too, we were interested in whether there is indeed a causative relationship between trauma and connective tissue injuries and if so, what can be the molecular details of the possible pathomechanism. We had difficulties establishing a human experimental model due to ethical reasons, the lack of biological samples (no access to professional dancers' tissues), and several possibilities for bias and confounding factors, such as dancers having different teachers, leaders, educational backgrounds, working hours and load, and genetic background.

Therefore, we chose to use animal models. Mammals show biologically preserved behavioral and neurobiological responses to valent stimuli, which emphasize the use of rodent models of PTSD (Verbitsky et al., 2020). Extensive comparative neuroanatomical studies support the rodent models in stress investigation (Verbitsky et al., 2020) because parallels can be found in regional vulnerability and functional consequences (Semple et al., 2013; Paximos et al., 2019). There are different rodent PTSD models in the literature (Richter-Levin et al., 2019) that can be categorized as physical, social defeat, or predator stress. From these models we considered choosing: Resident-Intruder Social Defeat, which takes 5 to 10 days, and there is contact with a novel aggressive resident, then a 24-hour housing with a resident, separated by perforated screen (Golden et al., 2011) but in this model, the quality of aggression is hardly controllable (Verbitsky et al., 2020), which disadvantage appeared in the Predator Exposure Stress model (Adamec et al., 1993), as well. Based on the favorable control of stressor intensity, our attention turned to the physical stress models, where Single Prolonged Stress (SPS) became our choice, which combines three distinct stressors (Liberzon et al., 1997) at once. Although dancers do not experience such type of stress, the selection of this model was supported by our methodological suspicion, that physical stress might induce more intensive alterations in the body, than social or predator stress. SPS participant animals show altered behavior such as sleep abnormalities (Vanderheyden et al., 2015) enhanced anxiety (Han et al., 2014; Liu et al., 2012), arousal (Khan & Liberzon, 2004), fear learning (Iwamoto et al., 2007), impaired spatial

awareness, recognition memory, and social interaction (Kohda et al., 2007; Wen et al., 2016). These changes are time-dependent (Liberzon et al., 1999; Knox et al., 2016). Researchers found alternations in certain brain areas, for example, in the hippocampus in the form of apoptotic markers (Liu et al., 2010), cell death (Lin et al., 2012), autophagosomes (Wan et al., 2016), enhanced oxidative stress, and inflammation (Schiavone et al., 2013). In the amygdala, increased apoptosis and downstream signals were found, for example, phosphorylated extracellular signal-regulated kinases and caspase 3,9,12 (Liu et al., 2010; Xiao et al., 2015). In the prefrontal cortex, apoptosis and dysregulated autophagy appeared (Li et al., 2013; Wen et al., 2016), elevated levels of protein kinase RNA-like endoplasmic reticulum kinase (PERK) caspase 12, glucose-regulated protein (GRP) 94 (Li et al., 2013; Zhao et al., 2014); a decreased level of glutamate (Know et al., 2010). The SPS procedure was also used to assess HPA-axis alteration with regard to PTSD (Keller et al., 2015; Knox et al., 2012).

Although we did not find scientific papers about Achilles tendon examination in rodents with PTSD model, we found studies, where the elasticity of the rodents' Achilles tendon was assessed without PTSD. In these studies, scholars measured the mechanical, compositional, and structural properties of the Achilles tendon of post-natal mice, (Ansorge et al., 2011; Mikic et al., 2010), used 3D analysis to evaluate the collagen fibrils of the Achilles tendon (Santorini et al., 2021), or tested its tensile strength properties (Shi et al., 2012). We also found similar studies with human Achilles tendon samples (Hangody, 2016), which all helped us design our study. We aimed to measure the tensile strength difference between the stressed and the control animals. We wanted to assess whether traumatic experiences altered the quality of the connective tissue, so abuse could truly be a risk factor for certain musculoskeletal conditions supporting our previous findings.

6.2. Methods

6.2.1. Animals

Forty C57BL/6 adult (14-18-week-old) male mice were used with a mean body weight of mean 29g. The animals were housed 3-6/group in standard polycarbonate cages (365 mm × 207 mm × 144 mm) at the animal facility of the Department of Pharmacology and Pharmacotherapy, University of Pécs in a temperature and humidity-controlled room under a standard 12-hour light/dark cycle (lights off at 18 h) with food and water available ad libitum. The animals were randomly assigned to experimental or control groups. The trauma and behavioral analysis was done during the early dark (active) phase of the animals between 19 and 23 h. During the trauma phase, half of the animals were stressed (SPS group) while the other

half remained undisturbed except for measuring their body weight (control group). Two weeks later all the animals underwent behavioral testing and 72 hours later were sacrificed by overdose urethane anesthesia. Their hindlimbs were collected immediately on dry ice. The experiments conducted on the animals were approved by the local committee for animal health and care and were performed according to the European Communities Council Directive recommendations for the care and use of laboratory animals (2010/63/EU).

6.2.2. Study design

Single-Prolonged Stress (SPS) was used to induce PTSD-like symptoms in mice (Maercker et al., 2004; Liberzon et al., 1997; Kohda et al., 2007; Konx et al., 2016). Although it is called a “single” prolonged stress, the procedure is comprised of successive, multi-modal stressors: Two-hour immobilization, twenty-minute forced swim, fifteen-minute rest, and exposure to diethyl ether until loss of consciousness. The steps of the procedure are shown in Figure 14.

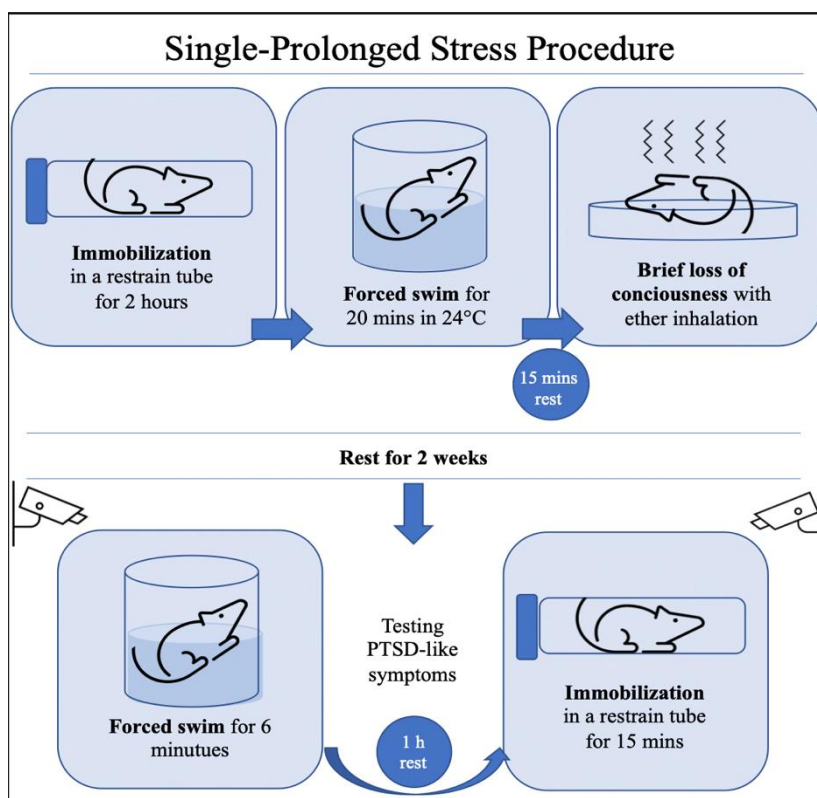


Figure 14: Single-Prolonged Stress (SPS) procedure steps we used in our study are described in this figure.

Stressed animals' restraint was performed in a 50 ml Falcon tube, into which mice were placed. After immobilization, we prepared 1400 ml, 24 ± 1 °C water in 2-liter-beakers to place the mice into them for forced swimming. Twenty minutes later we took the mice out, dried them with a paper towel, and let them rest for 15 minutes. Ether inhalation was done under the fume

cabinet one by one, controlling the overanesthesia. Each step was carried out simultaneously according to the original housing order, and each animal in a cage got the same treatment (either remained in control or underwent SPS). To test whether PTSD-like symptoms appeared in the stressed animals, we carried out behavioral tests: A 6-minute forced swim and 15-minute restraint with either stressed or control groups.

6.2.3. Behavioural Tests

The behavior of the animals was video recorded and later scored by a computer-based event-recorder software (Solomon Coder <https://solomon.andraspeter.com>, August 08, 2019) by an experimenter blinded to the treatment groups.

6.2.3.1. Forced swim test

Behavioral despair was analyzed as described previously (Porsolt et al., 1977). For SPS, each mouse was placed in a transparent glass cylinder filled with water (24 ± 1 °C) and submitted to 15 minutes of forced swim. During testing a similar FST was conducted for 6 minutes. Fresh water was used for each mouse and 3 to 5 animals were tested simultaneously in separate cylinders. After the test period, the mice were removed from the cylinder, dried with paper towels, and a clean towel was left in the home cage for 1 hour to avoid cooling. In the Forced Swim Test (FST), we distinguished three characteristic motions: Struggling, swimming, and floating. The time of immobility (floating) was expressed in seconds (Csöllei et al., 2013).

6.2.3.2. Restraint

Mice were put into a 50 ml plastic Falcon tube with several holes at the side and the cone to let there be for 2 hours during the SPS phase. For behavioral testing, a 15-minute restraint was conducted for all animals. 4 to 12 animals were treated at one time and the tubes were washed and dried between animals. In the Restraint Test, we distinguished two actions: Motion and freeze. As for behavioral scoring, the time spent struggling (tail and/or head movement) and its frequency were analyzed (Luchsinger et al., 2021).

6.2.4. Tensile strength test

In order to understand the Achilles-tendon biomechanical properties we established a tensile strength test. In this part of the research we were interested in to understand the possible mechanical differences between the stressed and control animals. Our main goal was to identify the flexibility of the tendon.

6.2.4.1. Test Machine

Tensile tests were carried out on a Zwick/Roell Z5.0 biaxial universal testing machine (ZwickRoell, 89079 Ulm, Germany) in room temperature of $23\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$. The crosshead speed was set to 10 mm/min without preload.

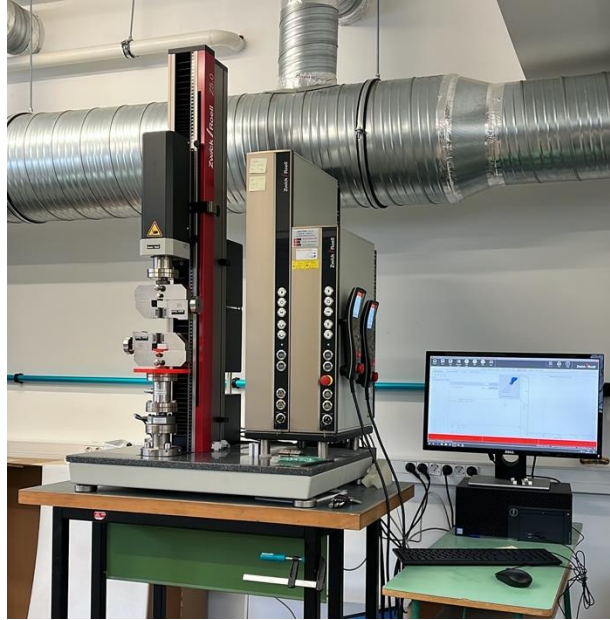


Figure 15: Zwick/Roell Z5.0 biaxial universal testing machine at University of Pécs, 3D Center

6.2.4.2. Clamp design

The greatest difficulty with mechanical tensile testing of tendons is its mechanical fixation in the testing machine due to its shapelessness and mucinous surface. Many types of clamps have already been tried for human tendons tests (Hangody, 2016). However, there is no standard procedure we could use. One of the best results has been achieved with the so-called Shi chuck (Shi et al., 2012). This clamp was scaled down and modified to suit our needs to capture the Achilles tendon of the mice. The clamp had to meet the following requirements: 1) Keep the tendon stable without damaging it; 2) All tendons should be able to be inserted in the same way (length, tendon interval); 3) Be compatible with the test machine chuck.

6.2.4.2.1. The development process

1) The size of the clamp has been reduced so the mice's Achilles tendon could fit in it. In the first trials, the tendons were dissected from the leg and muscle, which were so tiny that we could not fix it properly and for the most part they slipped out. The measured values were $6.83\text{ N} \pm 4.82\text{ N}$. We wanted to avoid freezing the ends of the tendon to avoid affecting the measurement.

2) Next, we designed a clamp where both the leg and the muscle were clipped to help secure the tendon. Therefore, on the muscle side, a funnel shape part was formed after the Shi profile, and a wider knurled part was formed on the foot side.

6.2.4.2.2. Printing technology

As an SLA technology, the Formlabs - Form2 (Formlabs, Somerville, 35 Medford St # 201, 3D) 3D printer was used, with standard white resin - V4 (FLGPWH04) and clear resin (Formlabs, Somerville, 35 Medford St # 201, USA). The layer height was 0.05 mm in the case of white resin and 0.025 mm in the case of clear resin. As a post-treatment process, a 10-minute washing in Ethanol was applied, then it was cured for 30 minutes at 60°C in Formlabs Form Cure IR chamber.

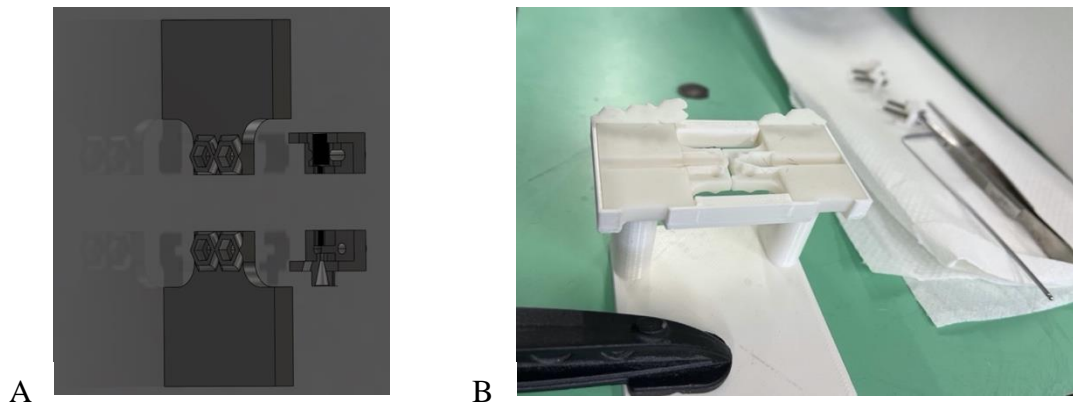


Figure 16: A) The design image of the 3D printed clamp, B) The clamp itself in a special holder to help the specimen fixation

During the test breaks, the lower resolution white resin proved to be better at $14.0 \text{ N} \pm 1.94 \text{ N}$, the blunter edges damaged the tendon less with still providing adequate support. The value measured with a clear resin clamp was $7.67 \text{ N} \pm 2.74 \text{ N}$. To ensure that the tendons were always inserted in the same way, we made a holder for the clamps and designed two 2 mm stops on one of the clamps so that the tested tendon length was 2 mm for all measurements.

6.2.5. Calculation and Statistical Analysis

To evaluate the tensile strength, we introduced Young's modulus, which gives information about the tissue's flexibility (Voigt et al., 1995). Young's modulus (E) is a formula that helps us calculate how easily a tissue can be stretched and deformed. This is a ratio of the

tensile stress (σ) and the tensile strain (ϵ). Tensile stress is the amount of force applied per unit area ($\sigma = F/A$). In our case, we used an average cross-sectional area of 0.65 mm (since we found no appropriate, standardized way to measure each of the samples) and the tensile strain was expressed as an extension per unit of length ($\epsilon = dl/l$).

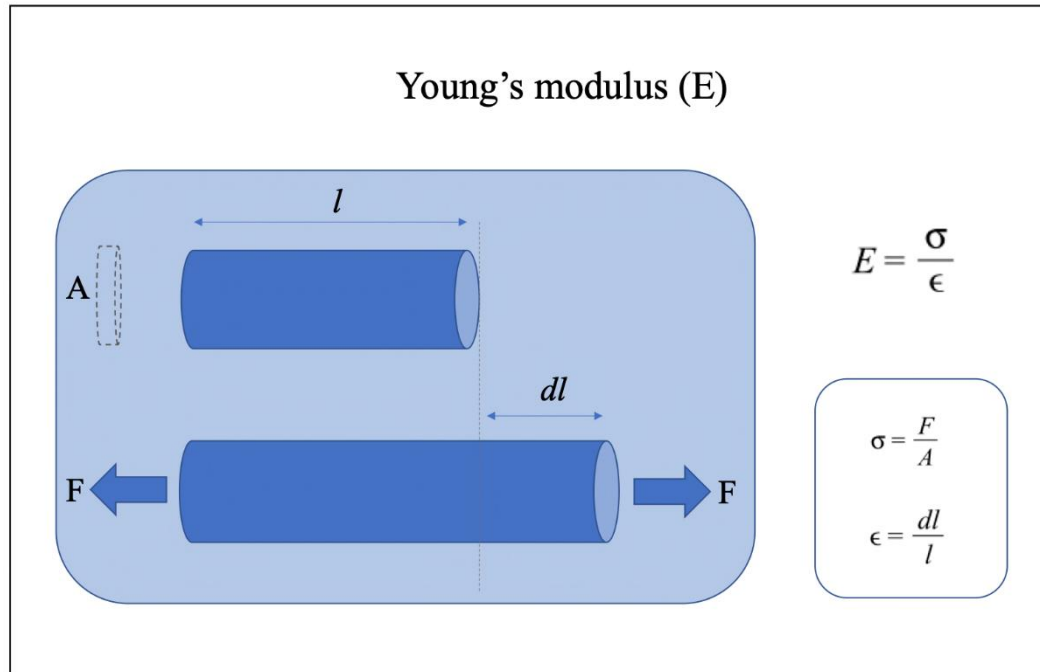


Figure 17: Description of Young's modulus

For the statistical analysis, we used OriginLab 2022 and SPSS 28.0.0. Normality was tested by Kolmogorov-Smirnov Test. Descriptive statistics were expressed as mean (μ) and standard deviation (SD), then statistical analysis was done to assess differences with a two-sample t-test and on variance by F-test. The behavioral tests were compared to the tensile strength results by Pearson's correlation, while Young's modulus of the two groups' relationship was described by regression methods. Outliers were removed when they were greater than two standard deviations away from the mean. The statistical significance was set to $p < 0.05$.

6.3. Results

6.3.1. Behavioral test

The results of the behavioral tests show that stressed animals developed PTSD-like symptoms. In the Forced Swim Test (FST), we distinguished three characteristic motions: Struggling, swimming, and floating. The mean struggling in the stressed animals was 54.1 s (SD = 15.8) while 93.58 s (SD = 21.1) in the control, and the results of the t-test for the duration of struggling between the two groups was $p = 0.0015$. In the Restraint Test, we distinguished two actions: Motion and freeze. The mean duration of the stressed group's freeze was 314.2s (SD = 76.5)

while 124.34s (SD = 50.7) for the control. The t-test for freeze showed a value of $p = 0.00045$. Thus, the SPS animals showed less struggling in FST and more freezing in restraint.

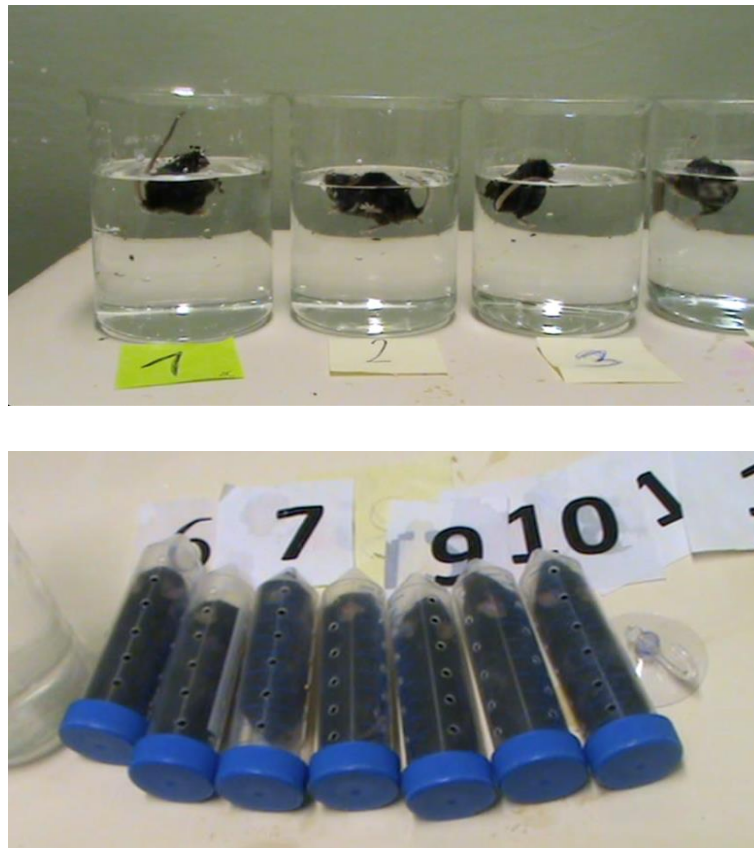


Figure 18: Forced swim and Restraint tests for PTSD-like symptoms identification
At the Forced swim test, we distinguished Floating, Swimming, and Struggling while at the Restraint test, we detected Freezing.

6.3.2. Tensile strength

We found no significant difference between the right or left leg either in the stressed or control group. The mean F_{\max} (tensile strength) was 24.98N (SD = 1.59) in the stressed animal and 20.87N (SD = 4.12) in the control group. The length difference was measured in millimeters where stressed animals had a mean of 0.566 mm (SD=0.084) and the control was 0.667mm (SD = 0.153). We have calculated Young's modulus, which was 1054.915 MPa (SD = 162.9) in the stressed group and 818.127 MPa (SD = 262.9) in the control group. The t-test showed a significant difference for the tensile strength ($p = 0.0058$) and Young's modulus ($p = 0.033$)

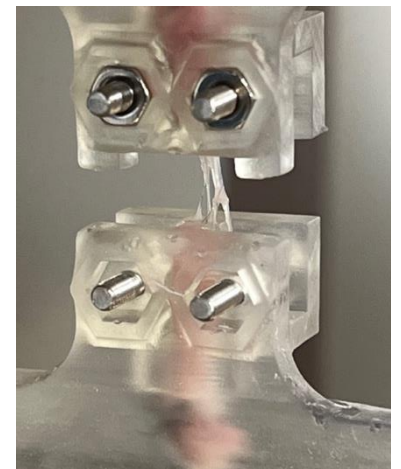


Figure 19: Strain of the tendon in the machine during the experiment

but not for the length difference ($p = 0.15$). The f-test on variability showed a highly significant effect for tensile strength ($p = 0.00083$), the length ($p = 0.0009$), and no significant difference between the groups for Young's modulus ($p = 0.14$).

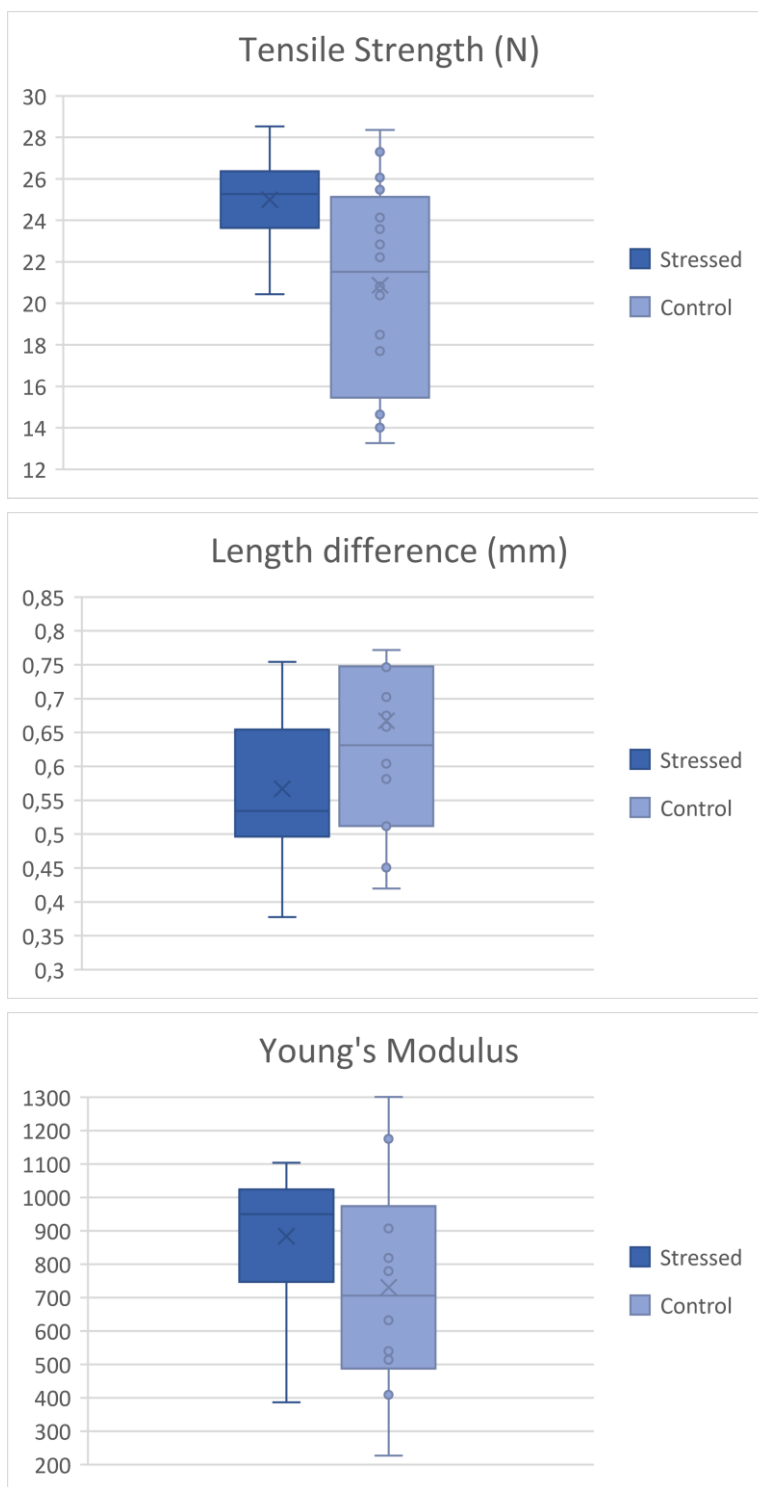


Figure 20: Comparison of Stressed and Control groups with the results of Tensile strength, Length difference, and Young's modulus. The data are expressed as mean and standard deviation.

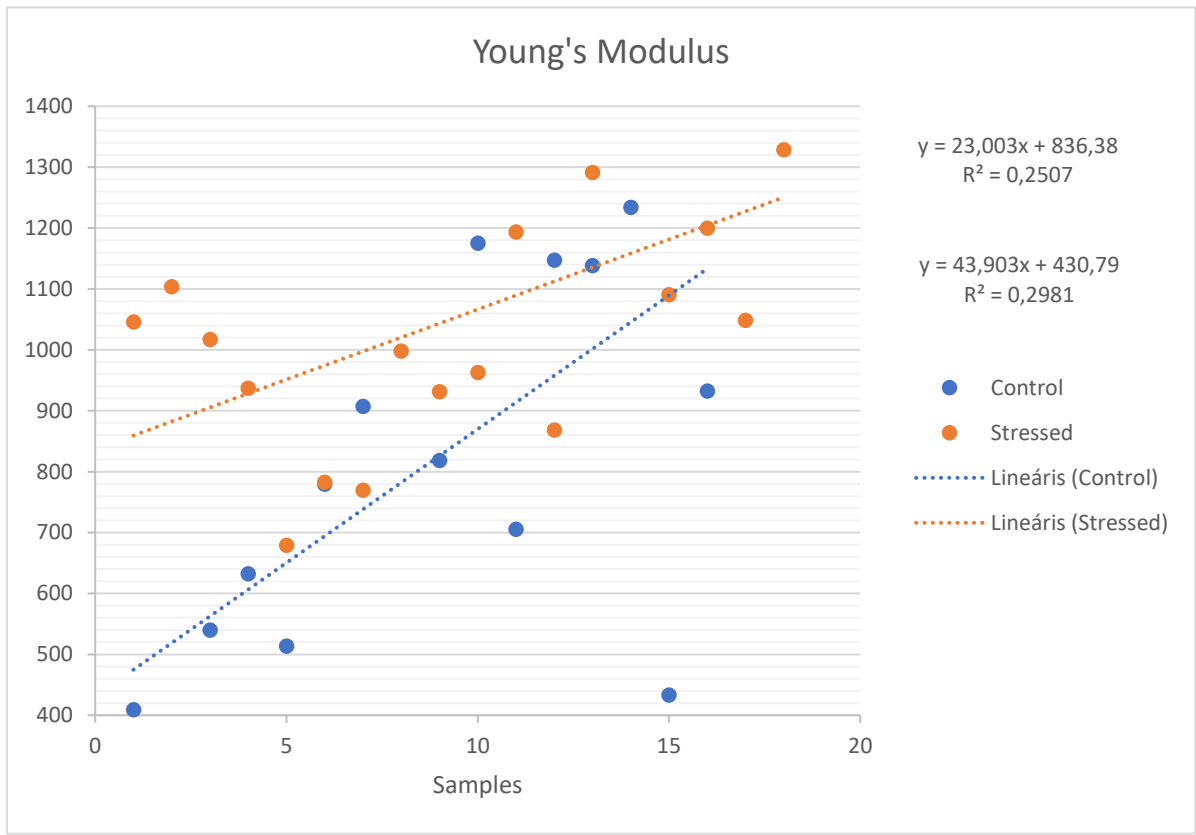


Figure 21: Linear regression showing Young's modulus between Control and Stressed animals

6.3.3. Relationship between the tensile test and behavior

Freeze and Floating durations positively correlated with Tensile strength (F_{max}) ($r = 0.749$ and 0.383 , respectively) and negatively correlated with length ($r = -0.602$ and -0.853 , respectively) in the stressed animals. Controls showed a weaker correlation between tensile strength and floating ($r = 0.15$) or freeze ($r = 0.29$), and moderate values between length difference with freezing ($r = -0.557$) and weak with floating ($r = -0.26$).

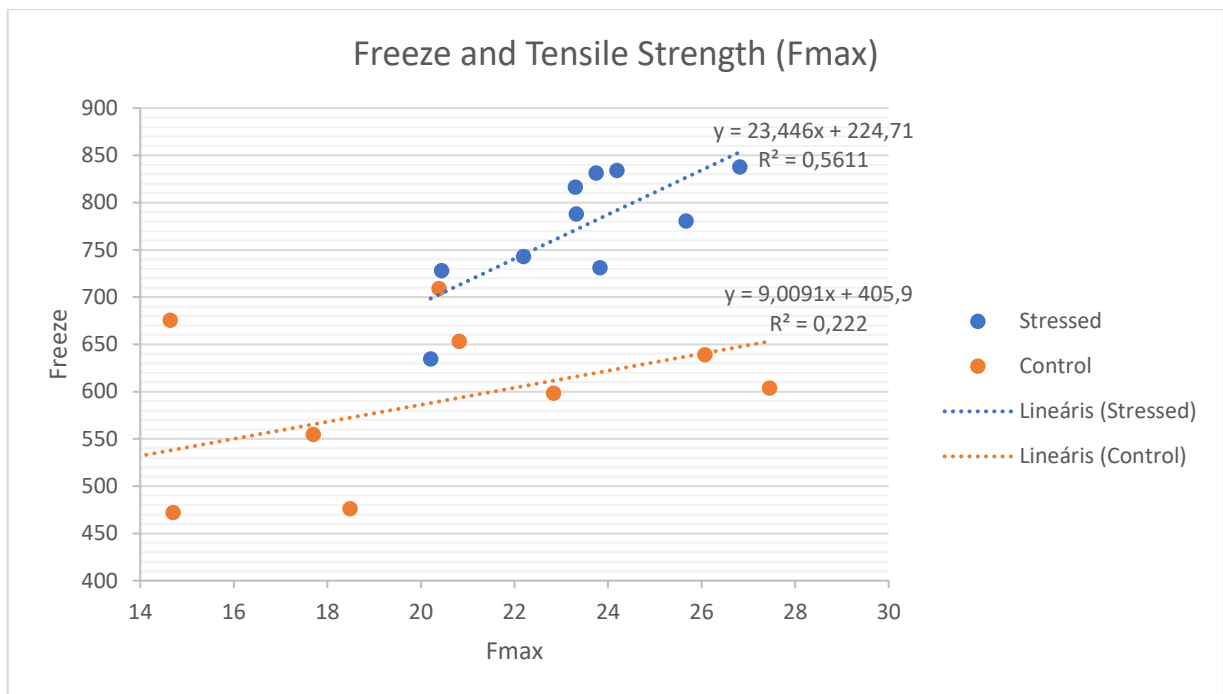


Figure 22: The linear regression showing Freeze (s) and Tensile Strength (N)

Young’s modulus was positively correlated with floating ($r = 0.49$) and freezing ($r = 0.56$) while negatively correlated with swimming ($r = -0.44$), struggling ($r = -0.38$), and motion ($r = -0.56$) in the stressed animals, while in the controls there were no or just a slight correlation with these behaviors ($r = -0.003$).

6.4. Discussion

In our hands, the SPS model worked as stressed animals spent significantly more time floating during FST and struggled more during Restraint than their control littermates. The behavioral tests proved that stressed animals developed PTSD-like symptoms. Our behavioral test results showed similarity to outcomes on SPS models in the literature (Nahvi et al., 2019; Souza et al., 2017).

There was no significant difference between the tensile strength of the right or left leg, that could alter our measured values in the tendon test. Thus, we used the average of the values on the two legs as a representative parameter for each animal. Moreover, the tensile strength values of the control group were similar to the ones found in the literature (Ansorge et al., 2011), which further confirmed the validity of our measurement. However, there was a significant difference in the mean values of tensile strength and Young’s modulus between the two groups. Young’s modulus was significantly higher in stressed animals, and the higher Young’s modulus, the stiffer the tissue is (Vaida et al., 2019), Thus, these results supported our hypothesis that the tendon’s flexibility may become impaired due to traumatic stress and the tendon vulnerability

may increase. We found that not only the mean difference but also the variance was significantly smaller in the stressed animals than in the controls. This gave us the impression that not only the flexibility of the tendons differed but the tissues' adaptation capability to certain exposures might be decreased. Our findings of altered connective tissue quality correlated with previously published data where bone alterations were found after 2 weeks of similar traumatic experiences (i.e., SPS) in rodents (Yu et al., 2014). We found a high to moderate correlation between certain behaviors and tensile strength so as with Young's modulus in the stressed animals' group. There are positive and negative correlations, which can be grouped into motion (motion, struggle, swim) and non-motion (freeze, floating) behaviors, where non-motion positively correlated with the measured flexibility results while motioning behaviors negatively. These correlations further supported our hypothesis that traumatic stress might causally contribute to the impaired tendons' flexibility and exclude the possible bias that certain motion factors or physical overload would make the connective tissue more vulnerable.

Although the injury rate of professional dancers is highly correlated with their physical overload (Roberts et al., 2013) and working hours (Leanderson et al., 2011; Gamboa et al., 2008), we suppose that their connective tissue injuries might not only originate from overload. These findings stand for the previously published model describing the possible relationship between Stress and Injury in athletes (Williams & Andersen, 1998). This way our previous qualitative and quantitative results of chronic and acute musculoskeletal conditions (ligament rupture, tendinopathy) could be explained in humans with its relationship to abusive acts. This study did not explore the molecular details of the pathological changes in the connective tissue of traumatized animals, so further research is needed in this direction.

7. Summary

In the last couple of years, since the 2017 #MeToo campaign, abuse became a hot topic in the creative industry. There were several public scandals where victims of perpetrators spoke up and shared their own stories. In Hungary, respected directors, choreographers, and ballet teachers were accused of abusive acts—either with sexual assaults and emotional or physical violations. Although these cases had a big influence on the general reputation of the dance world and the accused individuals, we found only a couple of international scientific papers dealing with this phenomenon either psychologically or physiologically. In this dissertation and during my Ph.D. studies, I was interested to discover the emotional abuse in the dance world and its possible health outcome by using the Bio-Psycho-Social approach.

Overall, we have performed qualitative and quantitative studies to assess professional dancers, where we were interested to understand the abusive atmosphere so as, the general and specific health conditions. Our studies were based on the previously found historical data and currently available “hot topic” cases from the press and theatrical literature, while we also performed a preliminary study and used personal experiences, which had a great impact on our research design.

In the qualitative studies, we found that the dancers we interviewed are in an abusive, toxic environment, including emotional and physical abuse (sexual abuse was not included in our research scope). Within emotional abuse, we found that body shaming, silent treatment, aggressive voice, and gaslighting were the commonly experienced forms. Dancers do not have individual interpersonal difficulties but are rather involved in systemic, multi-generational maltreatment, i.e., malpedagogy or malcoaching, which primary aim is to enhance performance and reach higher goals and not to causing harm or harass dancers. As it is not an individual problem, dancers have difficulties finding a supportive safe zone in the dancing facilities, where they could express their talent and use their creativity without being harmed. We found that dancers are in an uncertain working position since they do not have any employment security, including lucrative income opportunities, predictable timetables, or career models, which highly increases their vulnerability. While dancers work very hard in their careers, their physical and spiritual needs are not considered or respected, so regeneration is also being suppressed.

In the quantitative studies, we were interested in understanding the numerical and psychometric data, based on the previously performed interviews’ results. In this matter, one of our goals was to quantify the level of dissociation and stress level and mental health status

among them. According to our results, we concluded that dancers' dissociation level is high, a part of them belong to the pathological range, where around a quarter of them could be associated with PTSD. We measured dancers' chronic and acute musculoskeletal complaints where we could categorize chronic: Pain, inflammation, tendinopathy, and acute conditions. Lower back pain, as well as leg and neck pain, are overrepresented. We found a relationship and correlation between certain abuse experiences and musculoskeletal conditions. Nevertheless, there is a relationship between dissociation and perceived stress with musculoskeletal complaints, too. We concluded that abusive experience could serve as a risk factor to have chronic musculoskeletal conditions, moreover, the longer the dancer is in the abusive atmosphere, the higher the chance to suffer from the above-mentioned musculoskeletal conditions.

As we found a relationship between abuse and musculoskeletal conditions, our interest turned to investigating it further. According to the literature review, on the first hand, we were thinking about a biological study to assess immunological factors, but we could not solve two main problems: 1) decrease the selection bias—since professional dancers' population is small, confounding could be elevated since non-standardized factors such as stress exposure, working load, training background vary; 2) financial and infrastructural reasons. Evaluating these points, we have established an animal model with the University of Pécs Medical School, where I am completing my medical training. We were most excited about the relationship between musculoskeletal conditions and traumatic stress. In the animal study, we used the Single Prolonged Stress model, which is a commonly used PTSD model in animal studies. We sacrificed 40 mice to assess the Achilles tendons' flexibility between the stressed animals and the control group. For this purpose, we had to first create a special clamp that we architected and produced by 3D printers at the Faculty of Engineering and Information Technology, University of Pécs, where I am completing my master's degree in Biomedical Engineering. After several trials, we found the appropriate construction of the clamp to the accurate way of anatomical preparation of the Achilles tendon. We found significant differences in the flexibility of the tendon in the stressed animals, suggesting that traumatic experiences make the connective tissue more vulnerable. We also found a significant difference in the variance of flexibility data that predicts a lack of adaptation capability in stressed animals, which may also serve as a risk factor for connective tissue injuries. Although we could conclude that traumatic stress is a risk factor for connective tissue pathologies, further investigation is needed to identify the molecular pathomechanism in the background.

8. Limitations

First of all, we consider this study limited by the human sample size. Although the professional dancers' community has a low number of individuals in Hungary, and our quantitative sample size was appropriate by power calculation, we still hope for a higher number of involvement to support future results. Regarding the selection, we would be interested in the gender differences in abuse experiences, and the duration and time points of these acts. In our questionnaire for the abuse reported, we did not find validated scales, which may also limit our study results, however our validity testing showed statistically reassuring results.

Furthermore, the animal model has to be further analyzed with molecular biological methods to better understand the pathomechanism that was suggested in the results.

9. Conclusion

Professional dancers commonly suffer emotional abuses originating from an impaired way of coaching that involves generations of dancers. Dancers' vulnerability to abuses has increased by several external factors, such as uncertain financial status and the lack of employment security. Emotional abuse is a risk factor for certain musculoskeletal conditions, which is explained by the decreased flexibility in the connective tissue to tensile stress exposures. Although we understood the factors of the emotional abuse in the dancers' community, we have no exact suggestion on how to exclude these acts from everyday work, due to its multigenerational systemic existence, but we highly recommend the urgent change of the general atmosphere and working environment since emotional abuse not only has a mental health outcome, but it affects the physical health, too.

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14. Appendix

14.1. Questionnaire: *Abusive Experience Scale at Professional Dance (AECPD)*

	IGEN / NEM	YES / NO
1.	Pályája során tapasztalt olyat, hogy mestere, vezetője, koreográfusa agresszíven kommunikált Önnel?	During your career, have you experienced situations where your mentor, leader, or choreographer communicated with you aggressively?
2.	Pályája során előfordult olyan, hogy mestere, vezetője, koreográfusa testére bántó / sértő megjegyzést tett?	Have there been instances during your career where your mentor, leader, or choreographer made derogatory or offensive comments about your body?
3.	Előfordult olyan, hogy becsmérlően beszéltek Önről mesterei, vezetői koreográfusai mások előtt?	Has it happened that your mentors, leaders, or choreographers spoke disparagingly about you in front of others?
4.	Volt olyan, hogy gúnyos becenevet adott Önnek a balett teremben és azon szólította mestere, vezetője, koreográfusa?	Did your mentor, leader, or choreographer give you a mocking nickname in the ballet studio and address you by it?
5.	Előfordult olyan, hogy a balett teresmben a mester, koreográfus, vezető valamilyen tárgyat hajított volna, azért, hogy szavait erősítse?	Have there been instances where your mentor, choreographer, or leader threw an object in the ballet studio to emphasize their words?
6.	Előfordult olyan, hogy mestere, koreográfusa, vezetője kiabált Önnel?	Has your mentor, choreographer, or leader shouted at you?
7.	Előfordult olyan, hogy mestere, koreográfusa, vezetője azt mondta Önnek, hogy „ha ezt nem csinálod meg nem vagy a pályára való”?	Has your mentor, choreographer, or leader told you that "if you don't do this, you're not cut out for this career"?
8.	Volt olyan, hogy megszégyenítve érezte magát próba vagy gyakorlat közben?	Have you ever felt humiliated during rehearsals or practice?
9.	Előfordult olyan, hogy mestere, koreográfusa, vezetője fájdalmat okozott Önnek a helyes gyakorlat elérése	Have your mentor, choreographer, or leader caused you pain in order to achieve the

	érdekében (pl. belecsípett, rácsapott, meghúzta)?	correct technique (e.g., pinched you, slapped you, pulled you) ?
10	Volt olyan, hogy a mestere tanítói célból nem szólt Önhöz egy ideig (levegőnek nézte a teremben)?	Have there been times when your mentor, for instructional purposes, didn't speak to you for a while (ignored you in the studio)?

Articles related to the dissertation

Schwartz K, Vizin G, Boros S. Acute Musculoskeletal Complaints Vary According to the Perceived Stress Among Hungarian Professional Dancers. *Journal of Dance Medicine & Science*. 2023;0(0). doi:10.1177/1089313X23120047

Schwartz, K., Vizin, G., & Boros, S. (2023). Can Emotional or Physical Abuse Be a Risk Factor of Chronic Musculoskeletal Conditions in Professional Dance?. *Medical Problems of Performing Artists*, 38(3), 147-154. <https://doi.org/10.21091/mppa.2023.3018>

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