A Comprehensive Analysis of the Psychological and Biological Effects of Indian Classical Dance on Developing Female Adolescents

Riya Rakesh, Riya Thomas

Research Question: What are the psychological and biological effects of Indian classical dance on developing female adolescents?

Abstract

This paper studies the effects of physical activity and dance physiologically and psychologically. Specifically, it looks at how exercise impacts the nervous system, reduces stress levels, and improves muscle and cardiopulmonary function. This paper also delves into how exercise, dance in particular, affects adolescents' development, their stress levels, and academic performance. Existing research on the benefits of dance was furthered in this paper through qualitative pre- and post- dance class surveys completed by adolescent females participating in Indian classical dance. The goal of this paper is to educate adolescents and motivate them to partake in physical activities, such as dance, by giving a better understanding of the health and wellness benefits of physical activities.

Introduction

Physical activity is any movement that requires more energy than in the resting stage. Some examples of common physical activities are running, walking, and playing sports, like soccer and basketball. Participating in physical activity is essential, as they have numerous psychological and biological benefits, including improved function in the cardiopulmonary and musculoskeletal systems. Continuous participation in physical activity decreases the risk of various diseases like stroke, diabetes, hypertension, and certain cancers. It also helps maintain a healthy weight, which in turn is beneficial for managing rates of obesity, one of the major risk factors associated with increased mortality and detrimental health outcomes. People who are involved in physical activity are prone to a 20-30% decreased risk of death compared to those who lead sedentary lifestyles.

The psychological benefits of physical activity are improved cognition, focus, memory, and adolescent development. Additionally, physical activity helps with healthy growth and can help adolescents manage the negative outcomes of various experiences, such as social exclusion, that they may encounter. Lastly, it helps adolescents with daily and academic performance.

The Nervous System

The cerebral function of the body is divided into the central and peripheral nervous systems. The central nervous system (CNS) consists of the brain and spinal cord, while the peripheral nervous system (PNS) consists of everything else, like the nerves in a person's hands and feet. The central and peripheral nervous systems

communicate with each other about various bodily functions through electrical signals (*NICHD*, 2018). An example of this communication arc is the instinct to pull away one's hand when one touches a hot pan secondary to the relay of sensory information between the CNS and PNS to result in reflex motor reaction. The heat of the pan causes damage to the skin and activates certain receptors that induce electrical signals to pass within the brain, eventually leading to a response in the peripheral nervous system of pulling away one's hand.

Neurons and glial cells are the predominant cell types found in the CNS. Neurons or the nerve cells have the role of communication through electrical signals, while the glial cells provide structural support and allow neuron function. The overall purpose of the central nervous system is to receive, process, and respond to sensory information, like the five senses (sight, touch, smell, taste, hearing) (*NINDS*, 2024). Synapse is the space between the ends of two neurons, which allows for communication between neurons and is extremely important in order for neurons to receive information and to trigger the release of neurotransmitters (Figure 1). These electrical signals that are passed through the brain and spinal cord coordinate in the CNS and lead to a response formation in the muscles and organs via the PNS (*MHA*, 2020).

Neurotransmitters (NTs) are chemicals produced in the presynaptic terminal and stored within vesicles in the axon terminal (Figure 1). The four major neurotransmitters are serotonin, dopamine, glutamate, and acetylcholine. These endogenous chemicals allow neurons to communicate with each other throughout the body through a process called chemical synaptic transmission (Sheffler, 2023). This process occurs when there is a chemical stimulus, like hunger or exhaustion, that causes a change in electrical activity across the neural membrane. When the change in electrical impulse passes a certain threshold, it initiates an action potential that leads to the opening of a voltage gated ion channel (Grider, 2023). Calcium ions found outside of the axon terminal will move inside, since there is a lower concentration of calcium inside the terminal, which will then stimulate the fusion of the axon terminal's membrane to the presynaptic vesicle containing the neurotransmitter. This fusion triggers the release of the neurotransmitters which will then travel through the synapse and reach the receptors of the postsynaptic end of the adjacent neuron (Figure 1; *Khan Academy*, 2014). This process will continue until there is no further stimulus initiating action potentials (*NCBI*, 2001).

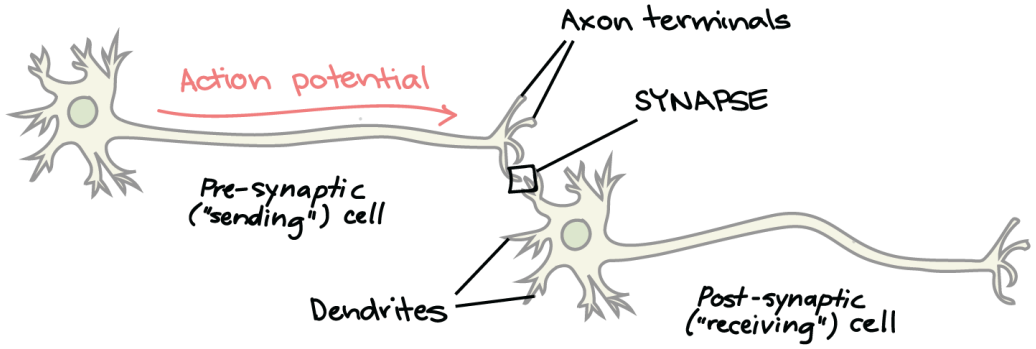

Figure 1: This figure depicts two neurons, one releasing the neurotransmitter and the other receiving it through the receptors. The synapse is the space between the two neurons. The action potential is what initiates the release of neurotransmitters from the axon terminal into the synapse, which then binds the receptors on the postsynaptic terminal of the adjacent neuron. (*Khan Academy*, 2014)

Various NTs are responsible for different emotions & functions. For example, dopamine produces the feeling of pleasure and satisfaction, and its main purpose is to help with functions like sleep, mood, and digestion (*Health Direct*, 2023). Any alterations in the levels of neurotransmitters can cause cerebral dysfunction, leading to various neurological illnesses like Parkinson disease, schizophrenia, depression, and Alzheimer disease.

Neurotransmitters are also involved in various stages of human development. For example, the levels of the neurotransmitter norepinephrine are high in the early stages of embryonic development, help to maintain blood pressure, and play an important role in a body's fight or flight response, otherwise known as the autonomic nervous system in the PNS (*Cleveland Clinic*, 2022). Glutamate is a neurotransmitter that helps with memory and mood and appears during the perinatal period, while monoamines help with the psychomotor, heart, and respiratory function before the neuronal differentiation (Pal, 2021; Yousuf, 2016). Similar to the function of monoamines, acetylcholine assists in the differentiation of various neural cells and acts as a morphogen, playing an important role in early human development as well (Sam, 2023). During adolescence, the levels of neurotransmitters, in particular dopamine and serotonin, change in the limbic system, which regulates emotion, behavior, and memory. The rise of dopamine levels increases the vulnerability to boredom, while decreased serotonin causes a change in mood and behavior, such as decreased excitement and recklessness (*Lumen*, 2015).

Since the CNS is very complex, there have been no definite answers to the reason why neurotransmitters are released during exercise. However, there are a few theories. One of them is that the joy and pleasure from doing physical activity can be a chemical stimulus leading to an increase in the number of action potentials. Another theory is that increased cerebral oxygenation facilitates the release of neurotransmitters. Exercise also increases brain-derived neurotrophic factor (BDNF), a protein that is essential for neuron function and survival, consequently playing a role in the release of neurotransmitters (*Oregon Health*, 2022). Studies suggest that the levels of these neurotransmitters can vary based on stress and exercise. For example the levels of neurotransmitters like endorphins, endocannabinoids, and dopamine are likely to increase with exercise (*Healthline*, 2023).

Exercise can also help reduce the levels of stress related hormones, like cortisol and adrenaline, which allows for better sleep and sharper thinking. When the body undergoes physical or mental stress, the primary stress hormone, cortisol, along with dopamine, epinephrine, and norepinephrine, are released (Scott, 2024; Fernstrom, 1994; Kobayashi, 2001). These hormones increase glucose in the bloodstream, which

repairs tissues and provides energy, and also mediate various functions of the CNS like motor control, memory, and cognition.

Cardiopulmonary & Musculoskeletal Systems

The peripheral nervous system consists of many different nerves, muscles, and organs. The heart and lungs are part of the cardiopulmonary system, and its main function is to control the circulation of blood and provide oxygen throughout the body. The muscles and its adjacent structures, which make up the musculoskeletal system, provide structural support and the means for movement.

On average, a human lung takes around 20,000 breaths per day and the heart pumps around 100,000 times (*Advent*, 2021; *British Heart Foundation*, 2021). The delivery of oxygen is governed by the diffusion capacity of oxygen and rate of mitochondrial oxygen consumption in muscles. Diffusion capacity is the amount of oxygen that can diffuse between the blood vessels and the muscles, organs, and lungs. The rate of oxygen consumption and flow is based on the levels of pO2, which is the partial pressure of oxygen in the blood. If the pO2 is low, that means the oxygen levels are low, which informs the body to increase the oxygen intake by breathing more frequently (*NCBI*, 2011).

The process of ventilation and perfusion all starts with the breath and the lungs. In one breath, oxygen goes down to the lungs through the trachea, a hollow tube that connects the passageways and allows for breathing from the mouth and nose. Then from the trachea, air goes to the bronchi, found in the lungs, then to the bronchioles, and finally the alveoli, a small bulb-like structure where perfusion occurs (*TED-Ed*, 2017). Capillaries lie adjacent to the alveolar membrane and the oxygen within the alveoli is diffused into the red blood cells in the capillaries (Figure 2). The red blood cells (RBCs), made from the hematopoietic tissue in the bone marrow, carry oxygen throughout the body with the help of proteins called hemoglobin (Billett, 1990).

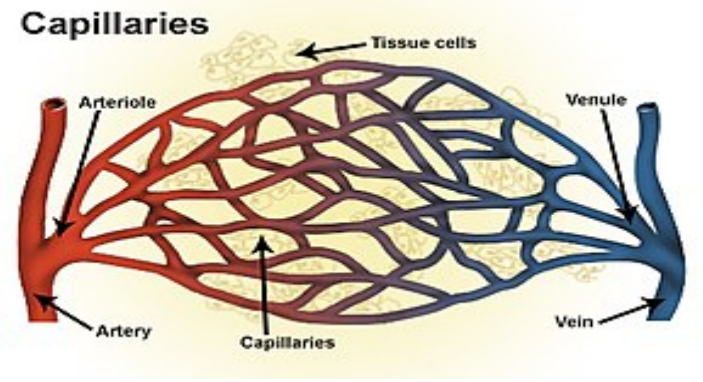

Figure 2: This figure shows the flow of blood from the artery all the way to the capillary, as well as its flow into venules and veins after oxygen diffusion is complete at the tissue cells. The red indicates oxygenated blood and the blue indicates deoxygenated blood. (*National Cancer Institute*, 2024)

Hemoglobin is a protein that binds oxygen within RBCs and hematocrit is the percentage of oxygen within the RBCs. If the hematocrit is low, that indicates that the levels of oxygen concentration is low (*Cleveland Clinic*, 2022). Once RBCs bind oxygen, they move from the lungs into the left atrium, then to the left ventricle, and are pushed out of the heart and into the blood vessels. The cardiovascular network is a very complex system with blood vessels reaching every part of the body. The aorta, or largest vessel branch of the heart, breaks down into the arteries, then arterioles, and finally the capillaries (Figure 2; *National Cancer Institute*, 2024). This network of vessels travel through the body to reach every cell and provide oxygen for various cell functions. Another protein that helps with diffusion of oxygen is myoglobin found within the muscles. This protein helps with bringing oxygen from the capillaries to the cells in the muscles. Therefore, the oxygen goes from the hemoglobin in the blood to the myoglobin in the muscles (*Cleveland Clinic*, 2021).

During vigorous physical activity, muscle cells consume oxygen to produce adenosine triphosphate (ATP), the molecule that provides energy for muscle contractions (Figure 3). In turn, the heart pumps faster to increase the rate of delivery and oxygen flow. Additionally during exercise, pO2 levels also increase, allowing better diffusion in the alveoli. Muscles also extract more oxygen from blood, which lowers venous oxygen content, allowing a more thorough flow (*American Lung Association*, 2024). This is essential to carry out various functions like the contraction of muscles, digestion, and even thinking. After these various processes finish, the hemoglobin within red blood cells help carry back carbon dioxide, the byproduct of ATP production, back to the right atrium, then the right ventricle, and to the alveoli in the lungs. Then it is diffused across the alveolar membrane and out of the body through exhalation. Then the cycle repeats continuously (*TED-Ed*, 2017).

That feeling of an achy muscle after exercise is due to the lack of oxygen within that muscle. The heart can not always pump blood fast enough during vigorous physical activity, which reduces the rate of oxygen delivery. This lack of oxygen will cause the body to switch from aerobic to anaerobic metabolism. Aerobic metabolism is when the cells use oxygen to produce carbon dioxide, water, and ATP from glucose. In anaerobic metabolism, cells produce lactic acid and ATP without oxygen. Lactic acid within the muscle causes pain, cramping and achiness. On the other hand, lactic acid can also fuel cells and muscles as they break it down into glucose, then this glucose will be used to produce more ATP, continuously cycling to produce more lactic acid (Figure 3; Pereira, 2022).

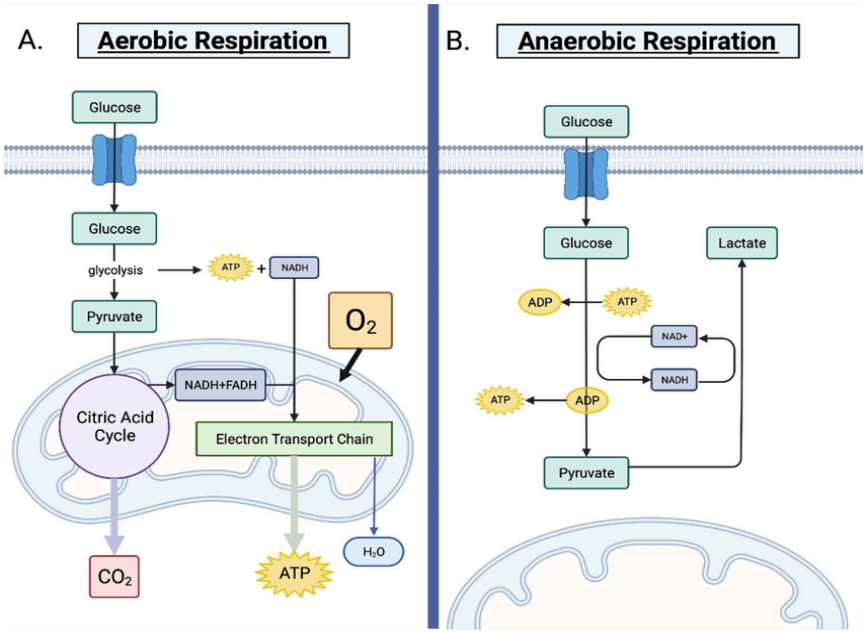

Figure 3: This image shows the difference between aerobic and anaerobic metabolism. Aerobic respiration results in CO_2, ATP, and H_2O, while anaerobic respiration produces lactate as a byproduct. (Pereira, 2022)

Exercise also increases the concentrations of both myoglobin and hemoglobin levels, allowing for better diffusion of oxygen throughout the body (Hu, 2012). Physical activity also increases muscle mass by constantly micro-stressing and repairing the muscle. The constant repair of the muscle fibers increases the formation of myofibrils, a protein that makes up the muscle and consists of actin, myosin, and support proteins, like tintin (Figure 4). More specifically, the micro-stress activates satellite cells which are found outside of the muscle fiber. As these cells multiply they fuse to the muscle fibers, which either helps with the repair of the microstress or forms new muscle protein strands. This formation allows for the cells' microfibrils to grow and increase (Kwon, 2004). The nuclei in these cells also help create more myofilaments and synthesize more proteins like actin and myosin.

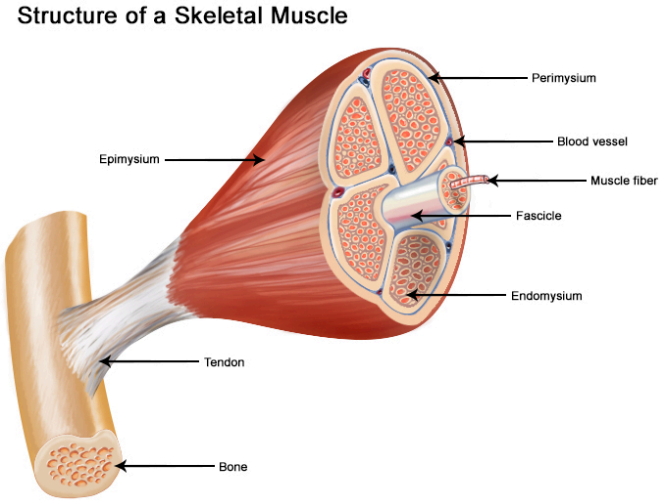

Figure 4: This figure shows the structure of the muscle. Muscles are formed from bundles of muscle fiber that coalesce to form fascicles that are surrounded by endomysium interiorally and blood vessels externally. Tendons attach the muscle to the bone. The micro-tear, repair, and building of the muscle occurs in the muscle fiber. (*National Cancer Institute*, 2024)

Although the exact mechanism is unknown, physical activity improves overall cardiovascular health by lowering heart rate, strengthening the heart, and reducing blood pressure and levels of stress hormones (*Mayo Clinic*, 2024). It also increases the density and flexibility of the capillaries that supply blood to the skeletal muscles (Fogoros, 2023). As blood flow increases, the nitric oxide found in the endothelial cells increases, which allows the blood vessels to relax and become more flexible (Skali, 2024). Exercise also increases the mass of blood cells secondary to improved environments in the hematopoietic tissue. Lastly, it improves the muscle's ability to diffuse oxygen out of the capillaries and into the myocytes, improving overall muscle function.

Stress & Anxiety

Stress is the state or feeling of worry, anxiety, and tension, and it is the natural human response to cope with difficult situations. There are three main kinds of stress: acute, episodic acute, and chronic stress. Acute stress are transient episodes, and it becomes episodic acute stress when these episodes occur on a regular basis. Chronic stress, on the other hand, is when these episodes last for weeks or even months. There are many things that cause stress, for example, pressure from peers, changes in daily life, and excessive workload. Stress can manifest in a person in numerous ways, such as physically in the form of headaches, high blood pressure, muscle tension and aches, or emotionally and behaviorally. Alternatively, it can also manifest psychologically in the form of depression or anxiety. These can result in decreased quality of life and lead to unhealthy practices, like gambling, substance abuse, and poor eating habits. Additionally, chronic stress can lead to permanent health issues in the immune, digestive, cardiovascular, and reproductive systems. For example, stress may cause changes in weight or lead to the formation of ulcers in the digestive system. Everyone copes with stress differently, whether it is through personal stress management practices, like exercising or meditating, or seeking professional help (*Cleveland Clinic*, 2024).

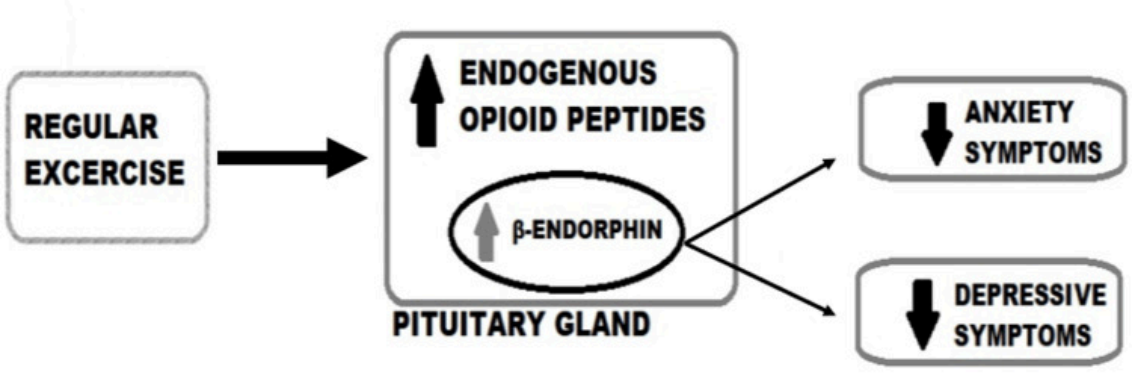

Figure 5: This figure shows how regularly participating in physical activity will increase the levels of endorphins, which are endogenous opioid neuropeptides. This will ultimately result in the decrease of anxious and depressive symptoms. (Mahindru, 2023)

Stress affects adolescents, especially teenagers, often due to pressure from school, extracurriculars, peers, or even family members (Beresin, 2022). Additionally, other factors, like active brain development or change in social experiences and relationships, may cause stress during this period. Stress affects adolescents' daily performance as it affects their mood, behavior, energy, motivation, appetite, and sleep patterns. Studies have shown that the rising popularity of social media in recent times has created a negative environment for adolescents, which may cause more stress and anxiety. A few ways for adolescents to manage stress is by avoiding harmful substances, getting proper sleep, creating a more positive mindset, taking time for themselves, and participating in physical activity (*AACAP*, 2019).

Physical activity has many benefits and one of them is how it reduces stress and anxiety. During physical activity the brain releases neurotransmitters which is what helps alleviate and decrease stress levels. The main neurotransmitter that is released during exercise is endorphins, which results in feeling more relaxed and happy (Figure 5). Exercise also reduces the amount of endogenous stress hormones, like cortisol, through an indirect mechanism leading to decreased anxiety, high blood pressure, and depression (*AADA*, 2022). Some of the common ways to reduce stress through physical activity is by walking, jogging, biking, playing sports, and dancing. Physical activity can help adolescents in multiple ways, such as by improving blood circulation, reducing stress, steading weight, boosting energy levels, and improving memory and sleep patterns. These benefits also extend to reduction in the development of various diseases from presenting in the future, like high cholesterol and blood pressure (Semeco, 2023) .

Academic Performance

Adolescents in the United States have many requirements that they must meet while they are enrolled in high school. This might include attending school for 8 hours/day to playing sports and volunteering or getting involved in extracurriculars over breaks and weekends. On average, adolescents in the US spend around 9.1 hours per week on homework from classes and 7.9 hours per week participating in extracurriculars (*NCBI*, 2019). In the US, students take around 5-6 core classes and electives (*College Vine*, 2024). Within those courses, there are honors and advanced placement (AP) classes which require more work and participation. The average student takes about 8 of these AP courses throughout high school. Additionally, students spend an average of 50 hours volunteering outside of school every year (Burger, 2021). Studies have suggested that all of this work and pressure to perform may be negatively impacting concentration, memory, and performance among students. Furthermore, depression and anxiety have become more common among teenagers, with one of the leading reasons being pressure from school (Mahindru, 2023).

In addition to reducing stress, depression, and negative moods, physical activity helps with cognitive process, learning, and recognition. It also increases blood flow to the brain and may play a role in neurogenesis, leading to an enhancement of cognitive skills like concentration, memory, and behavior. The teamwork and social skills developed from group physical activity, like sports, can also play a role in the classroom by teaching skills that are transferable to table discussions and presentations. The competitive nature of sports also fosters resilience, which can help students navigate difficult tasks and challenges during school. Additionally, physical activity can also lead to goal setting and development of leadership skills, which are transferable to the classroom, group projects, and other extracurricular activities as well (*YSN*, 2024).

These skills developed by partaking in physical activity not only helps with academics, but also can help with one's professional life. A study done by the National Institute of Health (NIH) suggests that students who are physically active tend to have better grades, attendance, performance, and behavior, likely secondary to improved concentration, focus, and motivation. Participating in physical activity, especially aerobic exercise, as a break in between academics and learning was found to be the most effective. It increased the student's attention span, on-task behavior, and performance in subjects like math and reading (*NCBI*, 2013). Adolescents, specifically, pre-teens between the ages of 9-11, seemed to be the most positively impacted by this practice (*NCBI*, 2013). Furthermore, exercise has been proven to improve both long-term and short-term memory, increasing the amount of information that adolescents can retain (Doherty, 2019). These benefits will cumulatively allow the child to perform better in school and create lifelong habits that are beneficial to their growth .

The Intersection of Dance & Stress Management

Dance is a type of physical activity that can be described as a sequence of steps usually matching the rhythm of a certain song. There are countless dance styles such as ballet, hip-hop, ballroom, and even styles specific to a culture or religion, like Indian classical dance. In many forms, dance often conveys messages or portrays stories and epics. In 2014, around 21 million people participated in dance in the US, and this number has steadily increased since then to about 26 million people in 2023 (*Statista*, 2024). Furthermore, female adolescents more commonly participate in dance starting at around the age of 4 (*Quicksteps*, 2023).

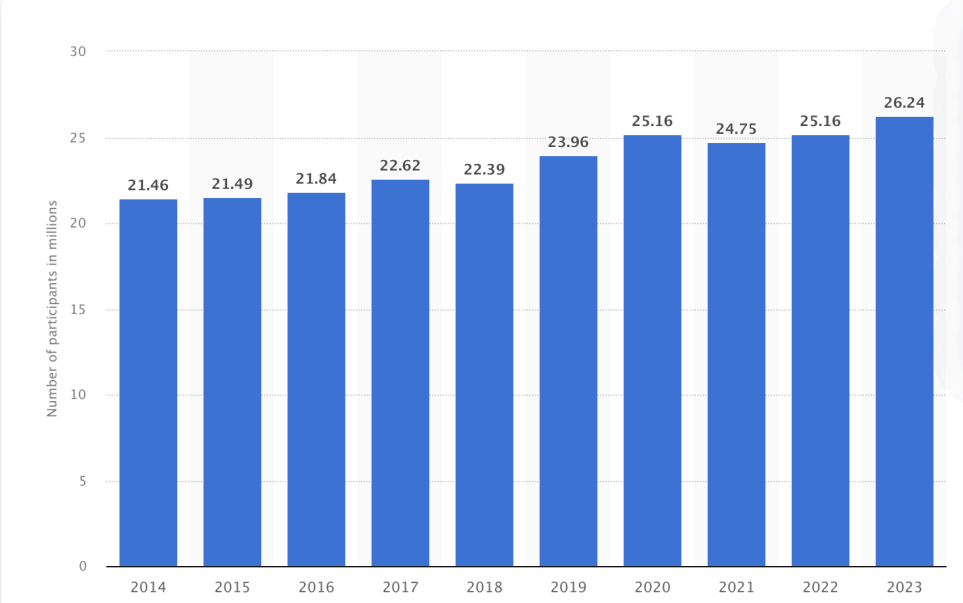

Figure 6: This figure shows the number of people participating in dance every year in the US. There has been an increase in participation in dance since 2014, from 21 million to 26 million. (*Statista*, 2024)

Dance has many biological effects like improving muscle strength, endurance, flexibility, balance, and spatial awareness. The side to side movements in dance strengthen bones like the femur, tibia, and fibula. Furthermore, the circular movements impact the lower back, hip joints, and ligaments, ultimately increasing the range of motion. Additionally, these movements facilitate better posture and reduce lower back pain. As a majority of movements in dance stem from the center of the body, dance requires core strength, and continuous participation will increase the abdominal muscle strength overtime. Dancing also activates various parts of the brain, like the cerebellum, the basal ganglia, and the midbrain. When these parts of the brain are activated, it allows for improved motor control and cerebral function. In adolescents, dance helps with sleep disturbances, growth, and musculoskeletal development. Like other forms of physical activity, dance also helps with the circulation of various neurotransmitters, like serotonin and dopamine, and neuromotor function, especially in children with Down Syndrome (DS). When dance is paired with other forms of physical activity, like yoga, it has been shown to reduce pain intensity (Lowney, 2018).

Dance also has numerous psychological effects, such as improved memory and problem solving skills. Memory improves as dancers have to remember the choreography and the rhythm of the song, and dancers develop problem solving skills as they work on their mistakes and learn how to manage time efficiently (*Bridgewater*, 2021). Moreover, dance helps the older brain form new interconnections and increase the temporal and prefrontal brain activity, which ultimately improves the memory capacity, the ability to multitask, and attention span. In adolescents, dance has been shown to help with management of mental health disorders, like depression, anxiety,

psychoticism, and obsessive-compulsive disorder (OCD). It improved the adolescents' daily quality of life, behavior and actions, and academic performance. It has also been shown to increase sensitivity and reduce hostility in adolescents (Lowney, 2018). A NIH study completed in 2012 suggested improved relationships between adolescents and parents after the children participated in dance for about 10 weeks. The study also suggested a positive change in memory capacity, inhibitory control, and cognitive flexibility (Tao, 2022).

Participant Demographics	Dance Interventions	Study design/Type of data	Key Findings
n = 122 female Age: 13–18 years old < Participants with stress related mental health problems	African dance, different choreographies to popular music in the show/jazz dance, street and contemporary dance genre	RCT Pittsburgh Sleep Quality Index	1. Dance intervention can be effective in decreasing daytime tiredness 2. Nonpharmacological interventions to decrease stress-related problems among adolescents
n = 80 both gender Age: 8.8 ± 0.7 years old Primary school children Australia"	Jazz - dance choreography	RCT 1. Working memory capacity 2. Motor competence 3. Cognitive flexilbity and inhibitory control	1. Dance practice coupled with a high cognitive challenge could improve working memory capacity and motor competence in children 2. The difference between groups was not groups
n = 36 both gender Age: 6-10 years old Children with DS India	Traditional India Dance	RCT 1. Test of Gross Motor Development–2 (TGMD–2) 2. Four Square Step Test (FSST) 3. Perdiatric balance scale Quantitative	1. The traditional Indian dance improved the locomotor skills of children with Down syndrome than that of neuromuscular exercises 2. Both the dance and neuromuscular training equally impacted the balance capacity
n = 55 both gender Age: 6-7 years old < Primary school students Australia	Specially choreographed dance routine	RCT 1. Executive functions (working memory capacity, cognitive flexibility and inhibitory control) 2. Motor competence Quantitative	1. Dance intervention improved inhibitory control and potentially working memory capacity 2. Dance intervention did not improve motor competence beyond typical development

Table 1: This table summarizes data adapted from the Frontiers study which shows various dance forms and how each one affects the human body. All of the dance forms tackle various things from memory capacity to motor development. (*Frontiers*, 2022)

Each form of dance can impact certain functions and processes in adolescents. African dance has been shown to decrease daytime tiredness and stress, while jazz can help with memory capacity and motor competence. Indian classical dance has been shown to be extremely beneficial for improving locomotor skills and balance capacity in children with DS, and specifically choreographed dances improved the negative psychological symptoms and modulated the levels of serotonin and dopamine in adolescent girls with mild depression (Table 1; *Frontiers*, 2022). Although each dance style has physiological and psychological benefits, the remainder of this paper will look more specifically at the benefits of Indian classical dance in relation to stress management and academic performance.

Indian Classical Dance

Previous studies have shown that Indian classical dance can be beneficial in adolescents with DS. To better characterize the benefits, I conducted a qualitative survey evaluating stress and energy levels of South Asian female adolescents between the ages of 13 to 16 who participate in Indian classical dance. The survey consists of general questions and questions quantifying stress levels. The general questions asked about their involvement in physical activities besides dance, the number of AP classes

they take, and the amount of time devoted to extracurriculars, while the more specific questions assessed their stress and energy levels on a scale of 1-5. Initially, eight people had their heart rate and oxygen levels measured with a pulse oximeter. However, three people declined to fill out the survey, resulting in five people for the survey.

The general demographics of the students showed that most of them have been dancing for around 11 years in total. On average, these students took around 2 AP courses and spent around 6 hours per week participating in other extracurriculars besides dance. The majority of dancers participated in physical activity, like walking, running, and biking, on a regular basis. These dancers also spend around 2½ hours practicing dance per week. Furthermore, these dancers get around 7 hours of sleep with about 1 episode of sleep disturbance during the night.

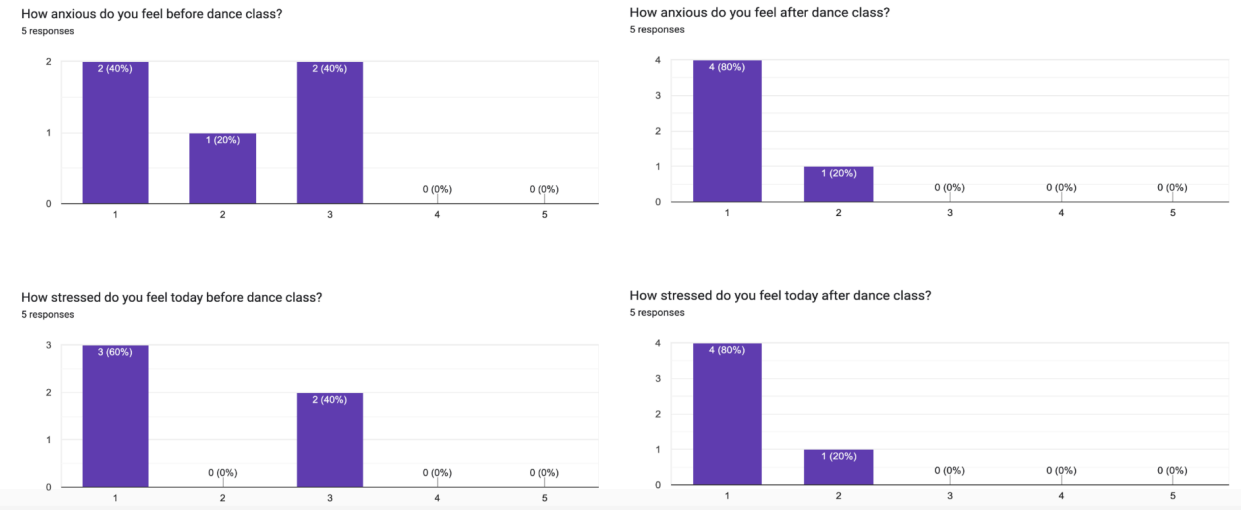

Figure 8: This figure shows the results from the pre- and post-survey. The survey was able to quantify stress through questions ranked with a scale of 1 to 5. Stress and anxiety ranged from 1 to 3 before class, and mostly decreased to 1 after class.

In 6 out of 8 dancers, their oxygen saturation and heart rate increased by the end of the class. The average oxygen saturation ranged from 99-100%, and the heart rate increased by 10-30 bpm. The survey found that there was a positive correlation between stress levels and amount of time needed to relax with involvement in school and extracurriculars. Overall, stress levels and anxiousness decreased for the majority of participants by the end of the class, although it remained the same for a few. The energy levels remained constant while physical tiredness increased in most individuals by the end of class (Figure 8).

The last question of the survey asked how these dancers felt after class ended and how dance makes them feel. In most of the responses, participants stated that dance was mentally relaxing and calming for them. A few people stated that dance made them happier and improved their mood. During dance class, they are able to let

go of stress from school, extracurriculars, and other work. It helped some people to feel more energized and empowered knowing that they were able to work with others to choreograph dances and finish a complex piece. Although dance was shown to be physically tiring, it was generally a great stress reliever and left its participants feeling calmer and happier. This survey suggests that dance is overall beneficial psychologically to developing adolescents.

Conclusion

In conclusion, physical activity benefits the body in numerous ways. Biologically, it improves cerebral, cardiopulmonary, and musculoskeletal functions. In the CNS, physical activity is a chemical stimulus for neurons that leads to the release of neurotransmitters. These neurotransmitters eventually lead to changes in mood, emotional regulation, and formation of behaviors. Physical activity also strengthens the cardiopulmonary system. During physical activity, the increased heart rate and respiratory rate lead to improved circulation and oxygenation respectively. Additionally, the increased rate of muscle contraction causes micro tears, which will induce muscle repair and the building of muscle mass. Longterm, continuous participation in physical activity will increase the amount of proteins, like hemoglobin and myoglobin, that carry oxygen throughout the body.

Psychologically, physical activity can affect mood, focus, mental wellness, and academic performance. The release of neurotransmitters that occur during physical activity can decrease the prevalence of anxiety and depression, as well as reduce the levels of stress hormones like cortisol. Additionally, participating in team sports enhances leadership and communication skills, which directly translate to improved daily and academic performance.

The survey confirmed prior study findings that dance increases heart rate and oxygen levels in the body. The survey showed several patterns that were common among the adolescents who participated in Indian classical dance, like decreased stress and anxiety levels. This data shows that physical activity, like dance, will help the body and mind in numerous ways.

The survey had some limitations, starting with the small sample size for the survey. Additionally, the survey was filled out by South Asian females and the results may differ for males or people of different ethnicities. The survey was also conducted with adolescents living on the West Coast, which limits the generalizability of the results as it did not include adolescents across the US. In the future, the survey should have a larger sample size with a broader age range, including elementary and middle-school students, as they do not devote as much time to extracurriculars and advanced classes as high-school students. Regardless, this survey still reinforced previous research findings, and demonstrated the biological and psychological effects of dance and physical activity. Overall, everyone who is physically able should participate in physical activity due to the substantial health benefits it offers.

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