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Sensory Intervention:
Does It Have a Biological Evidence Base?

Introduction

Many professionals outside of the occupational therapy world are deterred when they hear the words 'sensory processing.' Yet, the reality is that sensory processing has a major impact on the work occupational therapists do. Regardless of whether or not a therapist uses sensory integration techniques and modalities with a patient, the inner workings of the sensory system will influence a person's motivation, performance, affect, and engagement. In some cases, it's important for an occupational therapist to address a patient's sensory factors. Depending on the patient, this may involve providing education as to how sensory factors can be managed independently or implementing sensory interventions during sessions.

Each individual has a unique sensory system that can bring a range of variables into the plan of care. Such nuances can make it difficult for therapists to research efficacious sensory interventions and implement them in a way that's best for the patient. For this reason, it's essential that occupational therapists are aware of how to find, appraise, and implement reliable and evidence-based sensory interventions. This course will take a look at concrete biological measures and peer-reviewed studies that detail if and how sensory intervention can change a person's neurological function.

Section 1: Overview of Sensory Functions

1,2,3,4,5,6,7,8,9,10,11,12,13,14,15

When considering what sensory interventions are most effective for certain patients, therapists must first have a preliminary understanding of the sensory system, its components, and how each aspect of it functions. This is because each aspect of a person's sensory system is interrelated. For example, tactile defensiveness may place someone at a higher risk of sensitivity (defensiveness or otherwise) to another type of sensory input. Therapists must be aware of this connection in order to identify additional concerns that need to be addressed.

As a whole, the sensory system is part of both the central nervous system and the peripheral nervous system. When someone is exposed to sensory input, this triggers an electrical impulse (or signal) that begins in the nerves within the part of the body that experienced the input. The nerves then send the impulse to the brain, which rapidly processes the information and generates a response. The response is sent back to the nerves in the form of an electrical signal for the muscles to carry out. This is the outward action that a person displays to sensory input, and can include smiling, yelling, laughing, crying, grimacing, and a variety of other reactions based on how the brain interprets the input.

While the process is largely the same across various types of input, the sensory system is broken into general senses and special senses. General senses are largely touch- and position-related, and include pain, proprioception, vibration, pressure, temperature, and light touch. Each of these functions pertains to the tactile system. Special senses, on the other hand, include the visual system, auditory system, gustatory system, and olfactory system. These categories have been determined based on where the sensory receptors for each type are found in the body. In the case of the general senses, there are tactile receptors all across the body. Yet, when discussing the visual system, those receptors can only be found in the eyes.

Tactile System

Each special sense has various receptors and pathways that help carry information and generate purposeful responses to that input. There are 6 types of receptors in the tactile system: Merkel cells (or Merkel's discs), Pacini (or Vater-Pacinian) corpuscles, Meissner corpuscles (or tactile corpuscles), Krause end bulbs, Ruffini corpuscles, and free nerve endings. Each of these structures is located in the dermis, which is the layer of skin below the top level called the epidermis. The dermis is also home to sweat glands, hair follicles, blood, nerves, and capillaries. This allows each of the tactile receptors to attach to their corresponding nerve cells, which help them relay the information they take in.

Each of the above structures falls under the category of mechanoreceptors because of the type of input they help manage. Mechanoreceptors send external stimuli to internal structures through mechanically-controlled ion channels using electrical impulses. Meissner corpuscles are responsible for relaying low-frequency vibrations and light touch from the skin to the central nervous system, which is where they are processed and also where a reaction is generated. Merkel cells carry out the same sequence for pressure sensed on the skin. Similarly, Ruffini corpuscles relay input on stretch, Pacini corpuscles relay information on high-frequency vibrations, and free nerve endings send the brain input regarding pain. The fingertips, lips, and palms of the hands are considered some of the most sensitive parts of the body, and this is because these areas contain the highest concentration of Meissner corpuscles, which makes them especially sensitive to light touch.

Neurons that are part of the main tactile pathway are located in the principal sensory nucleus, or the PrV. The axons in this pathway connect to the large trigeminal nuclei, which is part of the trigeminal nerve. As a mixed cranial nerve, the trigeminal nerve receives touch sensation from several parts of the face and controls the jaw muscles to assist with chewing, speaking, and swallowing. As a whole the pathway starts at the posterior aspect of the medulla oblongata, which is a part of the brainstem that controls blood pressure, heart rate, and respiratory rate. From there, the pathway crosses the body's midline and extends to the third cervical vertebrae in the spine.

Visual System

The visual system is composed of several larger structures, including the retina, the optic nerve, the lateral geniculate nuclei (LGN) located in the thalamus, the striate cortex, the optic chiasm, and the geniculocalcarine tract (or optic radiations). The sensory receptors in the visual system are called photoreceptors. These are located in the back of the retina, and are responsible for changing visible light that enters the eye into images that our brain can process. The two types of photoreceptors in the eyes are rods and cones. Cones are responsible for a person's ability to see color as well as daylight vision. There are magenta cones that detect and process colors between red and green on the spectrum. Blue cones are responsible for shades of blue, and green cones are responsible for shades of green. Rods, on the other hand, are more sensitive to intensity of light. Their main function is to help someone see in low light conditions as well as assist with peripheral vision. For this reason, rods are located in the outer edges of the retina.

The pathway of the visual system involves some of the larger structures in the eyes along with the photoreceptors. Initially, light is reflected from an object in our environment to the cornea, which refracts the light through the iris and onto the crystalline lens. The lens transfers the light to the retina, which is where the rods and cones decode color and imagery. Once the objects have been processed, the retina sends the information to the lateral geniculate nucleus (LGN), which is located in the thalamus. The optic nerve is responsible for this transmission. From the LGN, information is sent to multiple parts of the cerebral cortex, including the striate cortex, which is responsible for initiating eye movements guided based on vision. Information is also sent to the geniculocalcarine tract, which sends information to the primary visual cortex in the occipital lobe of the brain.

This complete pathway occurs for both eyes so that we can obtain a complete, clear picture of what is before us. The optic chiasm plays a role in this by joining the optic nerves from each eye so the brain can receive all the visual information it needs to generate a response. Similar to the tactile system, the photoreceptors in the visual system also communicate using electrical signals.

Auditory System

There are a range of intricate structures that make up the auditory system. The ear alone consists of outer, middle, and inner sections, which contain even smaller structures that are integral to the auditory system. One portion of the outer ear, called the pinna or the auricle, is visible to us. The pinna is made up of several grooves on the upper part of the ear itself, which assist with collecting sound waves that then travel to the ear canal. The ear canal is another portion of the outer ear that amplifies sound waves from our environment. This canal also serves to protect the more delicate structures of the middle and inner ear from bacteria, dirt, and other foreign objects. The ear canal connects to the eardrum, also known as the tympanic membrane. The eardrum functions in a way that is similar to a musical drum – it vibrates when it is exposed to sound, which amplifies and clarifies what we hear.

The pathway of the auditory system continues from the outer ear to the middle ear, which contains three small bones (the incus, malleus, and stapes) that are crucial to our ability to hear. Collectively, these bones are known as the auditory ossicles. The malleus is hammer-shaped and connects directly to the eardrum. This allows the malleus to receive and transfer sound to the incus, which is shaped like an anvil and sends sound to the last tiny bone. The final structure in the middle ear is the stapes. This bone is shaped like a stirrup, and connects to the oval window, which is a gateway to the inner ear. The oval window is a thin membrane that covers the cochlea in the inner ear. The cochlea – a spiral-shaped structure that is filled with fluid – plays perhaps the biggest role in a person's hearing. It turns mechanical impulses into electrical impulses before transmitting the sound further along the auditory system. These electrical signals allow a person's brain to interpret individual sound waves, which greatly helps with the clarity and crispness of what they hear. The two remaining structures of the inner ear are the vestibule and the semicircular canals (the latter is also called the labyrinth). These two structures actually play a large part in someone's vestibular function, since they are responsible for a person's balance rather than hearing. In addition, the structures of the inner ear help someone maintain a sense of equilibrium and assist with spatial orientation.

Once auditory input travels through the components of the ear (from outer to inner), information is relayed to several parts of the brain for processing and interpretation. One of these areas is the cochlear nuclei, which are located in the medulla oblongata and receive input from the cochlea via the auditory nerve. Auditory input also travels to a cluster of cells called the superior olivary nuclei, which can be found in a part of the brainstem called the pons. The superior olivary nuclei help a person identify the location of sounds they hear. Auditory pathways also take auditory input to the lateral lemniscus. This part of the brain contains cells that indicate when a sound has begun along with other cells that are responsible for signaling a sound's duration. The lateral lemniscus originates in the brainstem and extends to the midbrain. The inferior colliculus is another part of the midbrain that is part of the auditory pathway, as it acts as the control center for nearly all sounds that enter the brain. In particular, the inferior colliculus is responsible for frequency recognition, discriminating pitch, and integrating auditory signals. The medial geniculate nuclei serve as an intermediary between the auditory cortex in the brain and the inferior colliculus, which we previously mentioned is in the midbrain. Last, but not least, is the auditory cortex, which offers higher level interpretation and conscious perception of the sounds our brain processes. The auditory cortex also plays a part in someone's ability to comprehend and express meaningful speech.

The auditory system also operates with the assistance of mechanoreceptors, which take the form of hair cells. These cells found in the inner ear, specifically the cochlea, are responsible for sensing head movement and sound in the environment. Mechanoreceptors related to the auditory system are called cochlear hair cells (also known as cilia), and they are highly sensitive as their response time to stimuli can be measured in milliseconds. When cilia are exposed to vibration from sound waves traveling through the eardrum, they emit electrical impulses that are sent to the brain through the auditory nerve. Humans have one row of inner hair cells and three rows of outer hair cells. The inner hair cells (which make up about 95% of the cilia in a person's ear) are the ones that send information to the brain, while the remaining 5% of the cilia receive electrical impulses from the brain in response to auditory stimuli.

Olfactory System

The main structures in the olfactory system are the nose and nasal cavities (more commonly known as the sinuses). The nasal cavity is lined with a thin layer of mucus-covered tissue, called the olfactory epithelium. Just as there are tiny hairs called cilia within the ears that assist with sound processing, cilia also play a role in the olfactory system and smell perception. The olfactory epithelium plays a distinct role in the process, as it is covered in cilia that trap odors as they travel across the barrier. There are two types of cilia in the nose – one form that protects the nose from foreign objects, bacteria, and anything else that may cause harm and another form that functions for sensory perception. The cilia that mainly serve a respiratory function are located at the posterior end of the nose, while the sensory cilia are closer to the front. This is also where olfactory receptors live. These sensory receptors generate electrical impulses based on the scents they hold, which are then passed along to the olfactory bulb via the olfactory nerve. The olfactory bulb acts as a relay that sends sensory information related to smell further along the olfactory pathway. If you follow the olfactory bulb further down the pathway, it eventually turns into the olfactory tract. This transition occurs on the posterior, inferior surface of the frontal lobe in the brain called the orbitofrontal cortex (OFC). The olfactory bulb also sends sensory information to the amygdala and the hippocampus, which both help someone translate olfactory input into memories. Olfaction is actually the only special sense that relays information to these two parts of the brain. This means a person's sense of smell is strongly linked to their memories, ability to learn, and emotions.

Gustatory System

The gustatory system, which governs a person's sense of taste, is made up of taste buds, gustatory receptors, taste receptor proteins, and taste papillae. Each of these are located on the tongue, which is the largest structure in the gustatory system. The taste papillae are the second largest part of this system, and they are most clearly visible on the tongue as raised surfaces. Taste papillae can also be found on the smooth palate (located at the roof of the mouth), the epiglottis (a small flap of skin that rests on top of the esophagus), and the pharynx (or the throat). A person's taste papillae contain taste buds. There are four types of papillae on the tongue: fungiform, foliate, circumvallate, and filiform. With the exception of filiform papillae, each of the aforementioned categories contain taste buds that process salty, sweet, bitter, umami/savory, and sour tastes. The filiform papillae, on the other hand, are cone-shaped structures that allow the tongue to discern sensory input other than taste (namely, the texture of what we eat). This type of papillae does not contain taste buds.

One type of receptor in the tongue also assists with managing sensations other than taste. Thermoreceptors detect heat-based sensations that arise from differences in the temperature of foods and beverages inside the mouth compared to the air inside the mouth. In addition, the mouth contains gustatory receptors that operate in relation to the chemicals a person ingests when they eat food. Based on the amount and type of chemicals a person's food contains, gustatory receptors release a certain amount of neurotransmitters. Gustatory receptors (or gustatory cells) in the mouth send these neurotransmitters to the brain using the vagus nerve, glossopharyngeal nerve, and the facial nerve. These three pathways are cranial nerves either solely or partly responsible for sensory input, so they bring gustatory information to the brain to be processed. Taste receptor proteins (G protein-coupled receptors, also known as GPCRs) can also be found in the taste papillae of the tongue and the soft palate. These are connected to afferent nerves that use the neurotransmitters to the gustatory cortex in the brain using the same cranial nerves that the gustatory receptors use.

Vestibular System

As we mentioned earlier, there is some overlap between the structures of the auditory system and the structures within the vestibular system. Structures of the inner ear, specifically the vestibule and the semicircular canals, are responsible for a person's sense of equilibrium rather than their hearing or auditory processing. In terms of vestibular function, the semicircular canals can be broken down into the anterior, posterior, and lateral/horizontal semicircular canals. These canals are ducts that connect various parts of the inner ear to one another. The semicircular canals are filled with fluid, which allows them to sense the direction and speed of acceleration at various angles that stems from certain types of head rotation. The anterior semicircular canal senses head movements that involve forward and backward motions, which may result from an action like nodding. The posterior semicircular canal, which is the longest of the three, detects tilting of the head such as that involved in touching your head to your shoulder when on the phone. The final semicircular canal is the horizontal (or lateral) canal that can identify when a person's head is moving side to side such as when they are turning to look at someone.

In addition to the semicircular canals, the vestibular system is also made up of the saccule and the utricle, also called the otolith organs. These are soft membranes or sacs that are also filled with fluid. The utricle can identify linear acceleration in a horizontal plane, while the saccule is more sensitive to the linear acceleration of the head in a vertical plane.

Due to the proximity of the structures in each system, the sensory receptors for the vestibular system develop alongside the sensory receptors for the auditory system. A sensory receptor called the macula is found on the bony vestibule of the inner ear. There is one macula on the saccule, and this receptor is attune to loud sounds and other vibrational stimuli. There is another macula found on the utricle, which detects changes in head posture. Each macula has columnar epithelial cells on its surface, which allows the structure to register movement in such a sensitive manner. Any stimuli that vestibular receptors receive is sent to the vestibular ganglion, which then takes the information to the vestibular nuclei in the brainstem via the vestibulocochlear nerve. The vestibular nuclei is connected to the spinal cord, thalamus, and cerebellum as well as the trochlear, oculomotor, and abducens nerves. Each of these offshoots is responsible for producing motor responses in response to the vestibular stimuli. Some examples of motor responses relevant to the vestibular system include eye movements (blinking, looking in various directions), reflexive actions (such as the vestibulo-ocular reflex, which helps someone stabilize their gaze while their head is moving), adjustments of the head and neck, and postural changes that assist with balance.

Proprioceptive System

As we mentioned earlier, the proprioceptive system differs quite a bit from the other systems in that it's a general sense. This means it's largely related to someone's sense of touch and position. For this reason, its mechanisms and even the structures involved in those processes are a bit unique. This is because the proprioceptive system must function across a person's entire body. The structures of this system understandably have some overlap with those related to the tactile system. However, there is also some overlap with structures that are in control of kinesthesia. Proprioception encompasses a person's subconscious awareness of their own movements. This includes a sense of the force on our muscles and the effort we exert through certain actions along with the general sense of heaviness from our limbs, torso, and body as a whole. In essence, someone is rarely thinking about where their body is positioned, but there is a sense of stability that comes from having that knowledge. For this reason, proprioceptive input is commonly regarded as a calming and orienting component of treatment. While proprioception is more subconscious, kinesthesia involves more conscious awareness of how our body is moving in terms of factors such as the direction, extent, and weight of motion. Both senses are crucial to a person's motor skills and body awareness, though each one plays a different role along the way. Another frame of reference for viewing these senses is that proprioception is more of a cognitive process and kinesthesia serves as more of a behavioral function.

The main proprioceptive structures include the muscle spindles, golgi tendon organ (GTO, which is sometimes referred to as a golgi apparatus), and receptors. In terms of the overlap, kinesthetic sense also utilizes muscle spindles, but only one of the receptors plays a part in both senses (skin receptors). Joint receptors do not assist with kinesthesia. The muscle spindles are located in a self-contained capsule that lies parallel to the skeletal muscle it corresponds with. These spindles serve as stretch receptors that indicate how long a muscle is, which functionally relates to whether it is engaged (contracted) or relaxed (elongated). In accordance with the muscle itself, muscle spindles stretch as a muscle lengthens and shorten when the muscle contracts. As their name may suggest, golgi tendon organs can be found where muscles meet tendons. GTOs are responsible for sensing and relaying information about how much tension a muscle is experiencing. In addition to offering information about muscle tension, golgi tendon organs also help initiate protective mechanisms that help someone avoid injury. If a golgi apparatus senses too much muscle tension in a particular spot, the structure uses a reflex arc to prevent the muscle from creating any force. In the case of someone who is lifting weights, for example, this lack of force will be a clear indication their body has reached its limit, since they will be unable to lift what's in front of them. These reflex arcs controlled by the GTO also preserve the integrity of a person's muscles if they stretch too quickly.

Joint receptors are another main structure in the proprioceptive system. As many of the other receptors we've discussed, joint receptors are mechanoreceptors. These are embedded in every joint capsule in the body. Joint receptors have a low threshold, which allows them to remain in tune with someone's movement - whether it can potentially cause injury or not. Receptors with this capacity offer someone a constant (and precise) stream of information about where their joints and limbs are. There are also sensory receptors in the skin (called cutaneous receptors) that relay data to the proprioceptive system. This is one of the main areas where the proprioceptive and tactile systems overlap. There are three cutaneous receptors in the body: nociceptors, mechanoreceptors, and thermoreceptors. Thermoreceptors gather stimuli pertaining to changes in temperature, specifically non-extreme data that helps our body sense when it is getting chilly or feeling flushed due to heat. Similar to the mechanoreceptors in the joints, cutaneous mechanoreceptors sense movement of the skin. Most skin movement takes place as someone's joints are moving, so information from cutaneous mechanoreceptors provides another layer of knowledge about someone's limb position. Nociceptors are responsible for transmitting information about pain, which understandably does some of the most work to protect us from injury. Some of the largest proprioceptive fibers, which are what make up these sensory receptors, can be found in the oculomotor nerve, trochlear nerve, and abducens nerve. These nerves also contain small fibers that innervate the nerve material found in the muscle spindles.

Kinesthetic information from these receptors is relayed to the dorsal column of the spinal cord via the thalamus and the medial lemniscus pathway that takes it to the cerebral cortex. In particular, the information reaches the sensory cortex of the brain, which is the parietal lobe. The parietal lobe not only combines information from multiple bodily senses and turns it into usable information, but this part of the brain also helps someone construct a basic understanding of the world around them. Proprioceptive information, on the other hand, travels to the cerebellum via the spinocerebellar tracts.

Section 1 Personal Reflection

How might an occupational therapist leverage the association between a person's sense of smell and their memory to motivate someone for treatment?

Section 1 Key Words

<u>Central nervous system</u> - One of the two main nervous systems in the body that consists of the brain, cerebellum, and the spinal cord

<u>Equilibrium</u> - A state of balance across all bodily systems, which is usually used to describe individuals at rest

Mechanoreceptor - A type of sensory receptor that uses electrical signals to send external stimulus to cells within the body; this information is transported across mechanical ion channels; mechanoreceptors commonly send information about stimuli in the form of stretch, pressure, sound, motion, and touch

Peripheral nervous system - One of the two main nervous systems in the body that consists of nerves connected to the brain and spinal cord

Thermoreceptor - A type of sensory receptor that picks up on the temperature of an object and sends this type of information to the brain to be processed

Section 2: Biological Markers Related to The Sensory Systems

16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47

Biological markers, also known as biomarkers, offer a snapshot of objective data about the internal processes of an organism, cell, or other biological structure. While biomarkers give healthcare providers insight into just a small portion of a person's bodily functions, they can still point toward certain health conditions that may be present. Biomarkers firstly provide information about a person's level of exposure to environmental toxins, which is related to the amount and type of chemicals in their body. Biomarkers also shed light on someone's response to such toxins since the body initiates certain biological processes as an attempt to break down chemicals that have entered its system. In addition, healthcare providers use biomarkers to measure someone's chances of developing symptomatology or health conditions. By understanding a person's genetic variations and testing their blood levels, providers can determine a person's risk of health conditions - either now or later in life.

There has been some research surrounding the biomarkers of neurodevelopmental conditions such as Autism Spectrum Disorder, Sensory Processing Disorder (SPD), and Attention-Deficit/Hyperactivity Disorder, all of which often have associated sensory concerns. Galiani-Simal et al. (2020) provide an overview of research on SPD and potential biomarkers that may be used to monitor treatment progress, including parasympathetic nervous system activity (those with SPD had lower PNS activity) and electroencephalogram readings (distinctive and unique patterns in those with SPD). In addition, this article mentions children with SPD have altered white matter microstructure in the absence of any neurological injury, which can be measured and monitored with diffusion tensor imaging (DTI). There is also some discussion about differences in the auditory and somatosensory cortical processing lobes noted via magnetoencephalographic (MEG) in those with ASD and SPD.

Other research has explored the efficacy of specific aspects of sensory intervention, including Dunn's Four-Quadrant Model of Sensory Processing. A Level 3 study by Metz et al. (2019) looked at the cross-over between behavioral responses, threshold axes, and symptomatology in healthy adults. Results showed that behavioral responses were mostly the same across individuals, but participants' thresholds significantly increased along the axis. In addition, introversion/extroversion subtypes of Eyseneck's personality model also did not vary in accordance with behavioral responses. This shows that Dunn's model appears to be independent of similar models such as Eyseneck's personality model. This offers credibility to Dunn's sensory processing model and its recommended interventions for certain patients with sensory processing concerns. However, researchers did note that there were small samples and participants who displayed low threshold patterns of processing or passive behavior regulation.

Biomarkers

Cortisol

Cortisol is a stress hormone that has an impact on nearly every organ system in the body. Yet, it's most commonly known for its most crucial job: moderating a person's stress response. Low levels of cortisol in the blood can be the result of issues with the pituitary gland, which controls the release of hormones. Individuals who have been under stress for long periods of time (qualifying as chronic stress when it persists for 6 months or more) will display low levels of cortisol in the blood. This takes place due to adrenal fatigue, since the adrenal glands will begin to have difficulty keeping up with the body's ongoing fight or flight response.

If cortisol is consistently prompting the body's autonomic functions to enter overdrive, the body will regularly have high cortisol levels that trigger fight or flight mode. This is why high levels of cortisol are associated with an increased heart rate, increased breathing rate, a spike in blood pressure, and interrupted digestion. High levels of cortisol in the blood may be the result of someone recently being exposed to stress or a stressful situation. However, high levels of cortisol are not always a bad thing, as these periodic surges of cortisol help the body manage inflammation, appropriately utilize glucose, and repair tissues. If someone's cortisol levels persistently remain high, though, this can lead to trouble.

It's well known that individuals with certain health concerns (such as intellectual disabilities and sensory difficulties) are more sensitive to stress than people without these conditions. For this reason, experts are attempting to explore the connection between stress, sensory difficulties, cortisol levels, and related conditions. Some research is looking to further explore the relationship between stress sensitivity and Autism Spectrum Disorder (ASD). A Level 4 study conducted by De Vaan et al. (2020) found that individuals with and without ASD had the same levels of salivary cortisol in the presence of a stressor. However, this study did find a relationship between cortisol levels and stereotyped or repetitive behaviors. This leads researchers to conclude that such behaviors are reactions to stress displayed by individuals with ASD. While occupational therapists do not always directly address repetitive behaviors, it is common for therapists to use techniques (sensory and otherwise) that minimize the impact of these behaviors on a person's functioning. That being said, this evidence supports the benefit of techniques to regulate cortisol along with behaviors that impact those levels.

Salivary Alpha-Amylase

Alpha-amylase (α-Amylase) is another biomarker that can be measured to assess a person's stress response as well as reactions such as overstimulation. In particular, salivary alpha-amylase is sensitive to bodily stress and is not associated with other stress-related biomarkers such as cortisol. This makes it a more easily accessible parameter to include in research studies. High levels of salivary alpha-amylase can be indicative of an infection, alcohol intoxication, cancer, an issue with the pancreas, or taking certain medications. Because of the role alpha-amylase plays in metabolizing starch, low levels of this biomarker can cause someone to develop insulin resistance. In addition, a lack of salivary alpha-amylase places someone at risk of diabetes as well as pancreatitis and cystic fibrosis.

Blood Pressure

This biomarker is a measure of the force a person's blood exerts on their artery walls. Blood pressure can be measured at several points in the body, since it is a measure of proper blood flow both to and from the heart. A person's blood pressure should be higher the closer you get to the heart. Blood pressure is a function of the autonomic nervous system, and it is one of the functions impacted by the body's fight or flight response. When a person's fight or flight response is engaged due to high stress or overstimulation, blood pressure measurements will rise due to narrowing arteries. When a person's fight or flight response abates, their blood pressure measurements should decrease.

The standard blood pressure measurement is between 90/60 mmHg and 120/80 mmHg. Anything above this range is considered high blood pressure, or hypertension, while anything lower than this range is considered low blood pressure or hypotension. The units of blood pressure measurement are millimeters (mm) of mercury, which is an element that is abbreviated using the letters 'Hg'. The first number in a blood pressure measurement is systolic blood pressure, which is an indication of the amount of pressure in someone's arteries when their heart beats. The second number in a blood pressure measurement is diastolic blood pressure, also known as a measure of the pressure in someone's arteries when their heart rests in between beats.

Individuals with chronically low blood pressure are likely to experience low energy and are at a higher risk of fainting, especially if they overexert themselves. People with high blood pressure are at a greater risk of many health concerns, including cerebrovascular accidents, myocardial infarction, and long-term vision problems. If high blood pressure goes untreated, it can also cause irreversible damage to the kidneys.

Heart Rate Variability (HRV)

Heart rate variability is defined as the variation in the amount of time between each of your heartbeats. In general, the variations between a person's heartbeats should be minute at a fraction of a second. While individuals may track their heart rate and other biomarkers with wearable devices, heart rate variability can only be measured with specialized medical equipment such as an electrocardiogram (EKG).

Low heart rate variability is an indicator of existing or potential health concerns, since it suggests the body is less capable of handling fluctuations. For example, individuals with ASD are known to have lower heart rate variability than peers without this condition. In addition, there is evidence to support the idea that fluctuations in heart rate variability (and a person's respiratory rate) impact their interoceptive abilities. Individuals with higher resting heart rates may also experience low heart rate variability, since there is less time between each of their heartbeats. High heart rate variability is associated with lower levels of stress, greater happiness, and increased adaptability. As a result, any interventions that aim to increase a person's heart rate variability are considered beneficial.

Evidence on Biomarkers & Sensory-Based Interventions

Aromatherapy

A Level 2 study conducted by Polonini et al. (2020) examined the impact of an intranasal blend of lavender and fennel on individuals with chronic stress. Participants used the product once daily before bedtime for 3 months. One group received a saline nasal spray, one group received a blend of 30% concentration, and the last group received a blend of 50% concentration. Participants in the groups that used the blends experienced significantly lower salivary cortisol levels after the study, and these gains persisted even 3 months after the study ended. Participants also reported improvements in sleep during the study, which also were seen at the 3-month check-in. In terms of limitations, the sample size for this study was small at 23 participants per group. In addition, participants reported some adverse effects such as an increase in restless sleep during the first week of use. Occupational therapists can use this data to inform home recommendations for patients who wish to improve their sleep and manage stress levels. In order to use such techniques in practice, therapists will likely need to make some adjustments to the method of service delivery for the sake of hygienically allocating resources. This may involve weighing the utility of intranasal sprays versus vials or diffusers that patients can inhale indirectly, though this may impact the efficacy of the technique. Therapists can use this modality with patients whose therapy performance is impacted by the effects of chronic stress.

A Level 2 study performed by Ogata et al. (2020) viewed the impact inhaling lavender oil had on biomarkers in healthy adult males. One group of participants inhaled a dose of lavender oil while another group inhaled a dose of distilled water. Both groups did this for a period of 20 minutes. Results showed that the intervention group experienced a decrease in self-reported depressive symptoms as well as a decrease in systolic and diastolic blood pressure. Limitations of this study include a very small sample size (7, in total) along with only focusing on young adult and middle-aged males without any notable health conditions. However, there is promise regarding further research, as this study yielded an increase in the concentration of oxytocin in the hypothalamus when performed on mice. For occupational therapists, aromatherapy can be a helpful adjunct to regulate biomarkers during treatment.

A Level 3 study conducted by James et al. (2021) looked at the possible effects of music and aromatherapy on pediatric patients with dental anxiety. Participants in one group were exposed to orange essential oil, participants in another group were exposed to music, and participants in the last group received neither of the interventions. Results showed that participants who were exposed to aromatherapy and music experienced a decreased pulse and respiratory rate. When the data was looked at more closely, researchers found that the music group yielded better outcomes than the aromatherapy group did. This study's main limitation was a small sample size, though there could also be variation seen in the type of music used based on a person's preferences and past experience. Therapists can use this information to inform practice when potentially combining these two interventions for an optimal outcome.

Auditory-Based Interventions

A Level 1 systematic review conducted by Sittler et al. (2021) took a look at 12 studies to determine the global impact of music on the stress levels of individuals with mild to moderate dementia. Most of the studies found that music led to a decrease in heart rate variability, but did not overtly affect alpha-amylase. The studies also found mixed results regarding the effect of music on blood pressure. As for music's impact on cortisol, one study found there was a decrease in salivary cortisol, while two other studies noted there was no significant difference in cortisol levels post-intervention related to music. In addition, three studies discovered that patients with severe dementia experienced increased parasympathetic activation after listening to music. Limitations of this review include failure to specify the types of music used for the interventions, which makes it more difficult for therapists to reproduce the same effects in treatment.

A Level 1 systematic review run by Erfanian et al. (2019) looked at the connection between certain biomarkers and soundscape. Soundscape is a music visualizer that allows individuals to simultaneously see and hear various sound waves. This review found that most people who used soundscape described it as pleasant and associated it with a higher level of arousal. In terms of biomarkers, the evidence that does exist shows that soundscape can assist with increasing someone's heart rate variability, regulate their skin conductance level, and lowering their respiratory rate. Soundscape has potential to be integrated in OT sessions to assist individuals who respond well to combined auditory and visual stimulation.

A Level 1 systematic review conducted by Hasani Helm et al. (2021) took a look at the impact of music therapy on children with ASD. The review looked at a total of 41 studies; of those, 30 studies analyzed the types of interventions used to manage symptoms of ASD while 11 studies looked at the vagus nerve in those with ASD. Results showed that music was effective in activating the parasympathetic nervous system through the vagus nerve in kids with ASD. This review suggested that music is an effective complement to other interventions for children with ASD due to its ability to assist in relaxation and stimulate the vagus receptors in the ear.

Deep Pressure & Proprioceptive-Based Interventions

The field of occupational therapy supports the utility of deep touch pressure, known to therapists as proprioceptive input, as a way to decrease a person's sympathetic response along with cortisol levels. Yet, it is important to have a scientific basis for this modality.

A Level 3 study conducted by Triscoli et al. (2017) compared the impact of light touch and the impact of upper body vibration on participants' cortisol levels and heart rate variability. Results showed that participants found the light touch more pleasant than the vibration, which corresponded with an increase in heart rate variability for the light touch only. Participants in both groups experienced a decrease in cortisol levels, which could point toward the effectiveness of both techniques at lowering stress levels or indicate a weakness in the study as a result of the supine positioning of the participants. Therapists may have difficulty replicating this type of touch in the absence of specific therapeutic devices, which can serve as a barrier to implementation.

A Level 2 study performed by Afif et al. (2022) analyzed the short-term effects of using two versions of an Autism hug machine portable seat (AHMPS) that offers deep pressure to children with ASD. A group of children used the inflatable wrap version for 20 minutes twice per week for 3 weeks while another group used the manual pull version for the same period of time. The notable difference between these versions is the mechanism they use to provide deep pressure. The manual pull version uses two leather-coated foam straps that are controlled externally by a person. The force exerted through the manual pull version is regulated by a pneumatic pressure technique. The inflatable pull also has straps, but mimics a balloon in its ability to grow larger and uses an air pressure sensor to monitor levels. The study showed that children in the inflatable wrap group experienced a significant decrease in emotional outbursts compared to little to no changes noted in children in the manual pull group. In addition, those in the inflatable wrap group also experienced a reduction in galvanic skin response (GSR) compared to no notable changes in GSR in the manual pull group. These results indicate that the inflatable wrap version is more effective in calming the body than the manual pull version. Such an outcome is likely due to the evenness and breadth of the pressure, which adds credibility and rationale to therapists providing patients with deep pressure over large surface areas of the body. The limitations of this study included a focus on children with ASD who were enrolled in specialized Autism schools along with a failure to measure the behavioral and cognitive factors of participants' parents, such as motivation, perception, and conditioning. These factors could have impacted the outcome measures. The study also could have been improved by collecting behavioral rating scales from teachers and comparing those results to the scales completed by parents. Researchers could even have looked more closely at the duration of the AHMPS and how that played a role in the outcomes. In using this study to inform practice, therapists should administer comprehensive assessments to a patient's entire care team in order to track progress. Therapists should also ensure that deep pressure equipment provides patients with consistency for optimal results.

A Level 1 systematic review conducted by Eron et al. (2020) – a group of occupational therapists – aimed to determine the effectiveness of deep pressure when provided by weighted blankets. The review included studies on weighted blankets used for the management of anxiety and insomnia. The review took a scoping look at four Level 1 studies, two Level 3 studies, and two Level 4 studies. Collectively, the studies supported the effectiveness of weighted blankets when used for anxiety, but there was little to no evidence backing up their use for insomnia. This particular review lacked any randomized controlled trials (RCTs), which are lauded as high-quality studies when conducted properly. The review also included a small number of studies, though the results can directly inform an OT's use of weighted blankets in practice to address symptoms of anxiety and related emotional discomfort.

A Level 2 study from Vinson et al. (2020) assessed the impact of weighted blankets on anxiety levels in individuals undergoing chemotherapy in outpatient centers. The study compared a group of individuals who used the weighted blanket during their first infusion with a group who used the weighted blanket during their second infusion. Results showed that the group who received the blanket during their first session experienced lower levels of anxiety than the group who received the blanket during their second session. This study emphasized the importance of using a medical-grade weighted blanket, which is a consideration therapists should ensure for their treatment. In addition, this study could be more efficacious if it identified and monitored the impact of the weighted blanket on anxiety biomarkers, such as gamma-aminobutyric acid (GABA).

Experimentally-Induced Pain

A Level 1 systematic review performed by Koenig et al. (2014) aimed to determine the relationship between heart rate variability, blood pressure, and various methods of experimentally-induced pain. The intent of this review was to identify how pain impacts someone's HRV and inform treatment approaches. The review included 20 studies that were conducted on healthy adults. The results of the review found that most studies elicited a spike in sympathetic-baroreflex activity along with a decrease in vagal-parasympathetic activity. These changes were characterized by changes in heart rate variability, specifically in the frequency domain of HRV. Sympathetic-baroreflex activity measures how effectively someone's baroreflex modulates isolated beat changes in a person's blood pressure in order to regulate this biomarker. The spike in this activity suggests that pain causes someone's body to adjust so there is not a major impact on their blood pressure. Vagal-parasympathetic activity controls most functions in the parasympathetic nervous system, which all change according to a person's fight or flight response, including digestion, immune function, heart rate, and breathing rate. A decrease in these functions is in alignment with someone involuntarily attempting to protect themselves from pain by their body entering a state of energy conservation. This was a relatively large systematic review, which offers a good scoping look at the research on this topic. OTs can use this information to gain a better understanding of the impact pain has on their patients. If therapists pair the results of this review with efficacious interventions that improve biomarkers such as blood pressure and vagal responses, they can more effectively address a patient's pain as part of treatment.

Diaphragmatic Breathing

A Level 1 systematic review by Hopper et al. (2019) looked at three studies that analyzed the impact of diaphragmatic breathing on physiological markers in adults. This review found that one study yielded an improvement in the cortisol levels as well as respiratory rates of adults. Another study showed an improvement in blood pressure (both systolic and diastolic) readings while the last study led to lower subjective reports of anxiety. It is of note that these studies each had a small sample size and the duration of the studies themselves varied largely from one 20-minute session to nearly one year. Since therapy sessions typically have a consistent frequency, this should not be as much of a concern in OT practice. However, therapists should educate patients and their caregivers about the importance of consistency when implementing home recommendations.

A Level 2 study by Baljon et al. (2019) led pregnant women through deep breathing exercises along with lower back massage and foot reflexology. The study measured the impact of these modalities on anxiety, pain, stress hormones, newborn outcomes, and duration of labor. Healthy women between 26 and 34 weeks gestation received the above interventions while a second group of pregnant women meeting the same criteria received routine midwife care. Labor pain and anxiety were measured hourly for 2 hours after the massage as well as during and after uterine contractions. Limitations of this study included the inability to blind mothers to the interventions and potential bias in self-reports for outcomes such as pain via the Visual Analog Scale. In addition, the level of experience that nursing graduates brought to the table while providing the interventions could have impacted the quality of treatment and, thus, the outcomes.

A Level 3 study run by Aranberri-Ruiz et al. (2022) addressed the relationship between deep, conscious breathing exercises through biofeedback treatment and heart rate variability in elementary students. Results showed that the group of students who underwent biofeedback sessions focused on deep breathing experienced lower reported levels of anxiety and an improved ability for conscious breathing. While this study had a large sample size of over 500 participants in total, the groups were not randomized. In addition, the study did not track the long-term retention and effects of such deep breathing practices. Researchers also posited that the improvements in anxiety levels may have been partially due to social support that arose from the group settings. While not all therapists have training in or access to biofeedback, OTs can pair deep breathing training and educational strategies to elicit a similar effect in certain patients.

Light Touch

A Level 2 study performed by Dreisoerner et al. (2021) looked at the comparative impact of self-soothing light touch and a hug from someone else on a person's stress levels. The results showed that participants in both groups demonstrated significantly lower cortisol levels afterwards, yet the heart rate variability and subjective reports of stress from both groups stayed the same. Similar to aforementioned studies on deep pressure, a major limitation in this study is the variation in pressure from the person giving a hug. In some cases, a hug may be more akin to light touch than deep pressure, which should be considered regarding its impact on study outcomes. This study also failed to isolate the impact of social factors such as feelings of belonging and emotional connectedness that may stem from a hug. In addition, individuals with tactile defensiveness are often sensitive to light touch, so light touch (even when highly controlled) may not be enjoyable to certain diagnostic groups. As such, patients may benefit more from self-soothing light touch as part of a home program alongside standard sensory treatments. This may allow high-functioning patients to gradually become more comfortable with that type of input.

A Level 2 study conducted by Edwards et al. (2018) sought to discover if light touch and deep pressure lead individuals to experience changes in heart rate variability, range of motion, and interoceptive abilities. Participants were broken into three groups: one that received deep pressure via head cradling, one that received therapeutic joint mobilization to the temporomandibular joint, and one that simply laid supine on a plinth. Results showed that participants who received deep touch experienced a significant increase in heart rate variability with some improvements in interoception, but the other two groups saw no changes in either variable. Participants across all groups did not see any improvements in range of motion. The results of this study suggest there is potential for deep pressure in the area of the neck and cranium. Therapists can explore this type of deep pressure as a way to better modulate the autonomic nervous system while improving the function of a person's interoception. This study did have a small sample size, and this study's focus on the jaw rather than another more commonly targeted part of the body also serves as a limitation. As with some other studies in this review, therapists should be mindful of difficulties that arise in accurately grading pressure when performing manual techniques as opposed to when using therapeutic equipment with pressure modulation as an embedded feature. This is another area therapists should be aware of as they incorporate such information into their practice. Specifically, this study could be a great way to inform therapists working with individuals who experience chronic pain.

Meditation

A Level 2 study conducted by researchers Bottaccioli et al. (2020) analyzed the impact of psychoneuroendocrinoimmunology-based meditation (PNEIMED) on the salivary cortisol levels of healthy college students. One group received 30 hours of training on PNEIMED while the other group received academic lessons. Salivary cortisol levels were measured at the start of the study and four days after the study concluded. The group that participated in PNEIMED displayed significantly lower levels of cortisol after the study compared to no notable changes in the academic control group. The study also found that individuals who received the intervention had higher levels of cortisol than the control group before the study began, which can be viewed as a potential study limitation along with the small sample size of the groups (20 participants in each) and the absence of health conditions in participants. Because PNEIMED requires some level of specific training, therapists may have difficulty replicating the modality. Yet, the basis of the study may still apply to other forms of meditation.

A Level 1 meta-analysis performed by Brown et al. (2022) looked at the relationship between mindfulness meditation and heart rate variability. The review assessed a total of 19 randomized controlled trials and determined there is not enough evidence to support a connection between vagally-mediated heart rate variability and this type of meditation. This particular meta-analysis attempted to reduce bias by limiting their scope to studies that looked at vagally-mediated heart rate variability since this has a clearer mechanism of action than other types of HRV.

Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Interventions

A Level 2 study from Dada et al. (2022) sought to discover the impact of MBSR on individuals with ocular hypertension. Participants engaged in one-hour MBSR sessions daily for 6 weeks and their outcomes were compared to those of individuals who did not receive MBSR. Results showed that individuals who received MBSR did experience a decrease in ocular hypertension. Ocular hypertension can potentially lead to glaucoma in some individuals, but it's not necessarily a major risk factor and, therefore, rarely impacts the work occupational therapists do. However, it is of note that participants in the MBSR group also displayed a significant decrease in blood cortisol levels and an increase in subjective quality-of-life after the study concluded. These outcomes allow therapists yet another avenue to help patients manage overstimulation, anxiety, and other related concerns.

A Level 1 systematic review conducted by Tung et al. (2019) looked at 18 studies that assessed the relationship between mindfulness and heart rate variability. Half of the studies involved an MBSR or mindfulness-based cognitive therapy (MBCT) program spanning between 4 and 10 weeks. Other studies involved less structured mindfulness or one-time, brief sessions. The majority of the studies showed that 8-week mindfulness training sessions were the most effective, as results demonstrated significant increases in heart rate variability as a result. This review's most notable limitation was the wide variation in the specific type of intervention (some were MBSR, some were MBCT, and others were brief and less structured) as well as the variation in the time of interventions studied. Regardless, this data can be used to emphasize the importance of long-term training, not only for the sake of achieving optimal treatment results, but also for ideal carryover.

Progressive Muscle Relaxation (PMR)

A Level 2 study put together by Park et al. (2018) took a look at the impact of progressive muscle relaxation on dental anxiety. One group of participants took part in a 20-minute PMR session and 15 minutes of oral health education once per week for four weeks. Another group received only oral health education for the same period of time. Researchers monitored outcomes at the 4-week mark as well as 3 months after the study. The intervention group displayed significantly greater reductions in anxiety, depression symptoms, blood pressure (both diastolic and systolic), pulse rate, and salivary cortisol levels when compared to the control group at both the 4-week mark and the 3-month mark. This study showed promising results, though the sample sizes were small (34 participants in each group) and the participants did not demonstrate health concerns outside of circumstantial anxiety. However, it does offer information that can be carried over to patients who demonstrate anxiety during OT sessions. Therapists should also be mindful that progressive muscle relaxation is contraindicated with individuals who have chronically high blood pressure or cardiovascular conditions.

A Level 2 study conducted by Ozhanli et al. (2022) aimed to measure the impact of progressive muscle relaxation on individuals undergoing colorectal surgery. Patients in the experimental group were led through progressive relaxation exercises for 15 minutes both before surgery and on days 1, 2, and 3 of their postoperative recovery. This training took place right after training on breathing exercises. Results showed that the individuals who participated in the relaxation techniques reported lower pain and lower anxiety levels after their surgery as compared to the control group. In addition, participants who engaged in the intervention utilized less opioid pain medications on the same day of their surgery as compared to individuals who did not receive the intervention. Blood cortisol levels, heart rate, blood pressure, respiratory rate, and oxygen saturation were unchanged as a result of the intervention. While this was a small study, occupational therapists can use the results to inform pairing of interventions. As individuals were being monitored while still in the hospital, the study did not take into account anxiety, overstimulation, and other responses stemming from that.

Traditional Yoga and Yoga Variations

A Level 2 study by Ozturk et al. (2021) aimed to explore the effectiveness of laughter yoga on healthy university students who reported high levels of stress. Results found that salivary cortisol levels significantly decreased in the intervention group when compared to the control group. This effect was noted as early as session three out of the eight projected sessions. Limitations of this study include subjective symptom tracking taking place only after the first and last session and not throughout the course of the study as occurred with the cortisol levels.

A Level 1 systematic review by Alici et al. (2020) was also conducted on the impact of laughter yoga on older adults. This review demonstrated great range as it analyzed a total of 3,210 studies across 7 publications. Results showed that participants who engaged in laughter yoga experienced a decrease in blood pressure, lower cortisol levels, improved sleep quality, and subjective improvements in quality-of-life. While there may be specific training involved in guiding patients through laughter yoga, therapists can likely incorporate aspects of this into sensory integration treatment to reap similar benefits.

A Level 2 study performed by Paungmali et al. (2018) analyzed the impact of core stabilization exercises in individuals with chronic, nonspecific low back pain. One group of participants completed the exercises in crook lying and rest (supine with knees bent and the soles of one's feet flat on the ground) and another group assumed this same position while using an automatic cycler. The last group completed lumbopelvic core stability exercises (LCSE) using a Pilates device. Results showed those who completed Pilates-based LCSE exercises experienced a significant increase in plasma β-endorphins compared to the other two groups. Plasma cortisol levels were unchanged across all three groups. Limitations of this study include the absence of isolation regarding the effects of an endogenous opioid mechanism and stress-induced analgesic mechanisms that may each be impacting endorphin levels in different ways.

A Level 2 study performed by Harrison et al. (2004) explored the link between Sahaja Yoga Meditation (SYM) and treatment outcomes in children with ADHD. Parents and children jointly took part in a 6-week program involving clinic sessions twice per week and regular meditation practices at home. Post-assessment questionnaires showed that participants experienced an improvement in ADHD symptoms, enhanced self-esteem, and a stronger relationship between parent and child. In addition, children reported improvements in anxiety levels, more regular sleep patterns, improved ability to focus, and less interpersonal conflict. Parents reported improved mood on their behalf along with lower stress levels, and improved ability to help manage their child's behaviors. This intervention is particularly in line with the worldview of occupational therapists, as it would allow therapists to provide more collaborative, patient-centered treatment.

Visual Interventions

A Level 2 study conducted by West et al. (2019) studied the impact of naturalistic light on individuals who have experienced stroke while admitted to inpatient rehabilitation facilities for a period of 2 weeks. The study measured each participant's serum cortisol levels along with their plasma melatonin at the time of their admission, the time of their discharge, and for 4 hours over a 24-hour period. Results showed that the participants who were exposed to naturalistic light experienced higher levels of plasma melatonin at the time of discharge as compared to those who stayed in rooms with standard hospital lighting. Participants in the naturalistic light group also demonstrated a more definitive sleep-wake rhythm than those in the other group. Cortisol levels were similar across both groups between the start and finish of the study. Limitations of this study include the light being an environmental modification (indirect intervention) rather than a direct sensory strategy. This may have played a part in the outcomes it contributed to. The study also had a small sample size with a total 43 participants across both groups.

Section 2 Personal Reflection

If a therapist was interested in using an intervention that provided deep pressure on a patient during treatment, what type of deficit might this patient demonstrate? What is the general consensus regarding the efficacy of deep pressure on certain populations?

Section 2 Key Words

Baroreflex - A reflex that assists with homeostasis in keeping someone's blood pressure steady in response to external and internal variables such as injuries or health conditions; this is also known as the baroreceptor reflex

Endogenous opioid mechanism - An innate pain-relieving system that consists of three opioid neurons found throughout the body

Interoception - The ability to sense signals within your body; for example, feeling one's chest fill up with air after taking a deep breath or hearing your heart beating

Joint mobilization - A manual therapy technique that involves various levels of movement in order to temporarily decrease pain and improve function

Visual analog scale (VAS) - A ten-point measure that is used to assess pain intensity using a visual scale

Section 3: Applying Sensory Integration Research to Practice

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The range of research available offers therapists a wealth of information that can inform their practice. As mentioned, many of the above studies had small sample sizes and other limitations that can impact their reliability compared to other peer-reviewed studies. However, much of the research supporting these sensory-based interventions is in support of the techniques. Therapists should keep in mind that it's ideal to use sensory-based interventions with standardized protocols such as the autism hug machine portable seat and others. Interventions structured off Dunn's sensory processing model are another example of treatments with a high level of credibility. By using interventions with more rigid parameters, this will ensure patients get the optimal benefit. In the same vein, therapists should emphasize consistency when instructing parents and caregivers about home programs for carryover. Multi-sensory techniques – such as music visualization – are also beneficial for patients since they work toward an ultimate goal of sensory integration rather than focusing on a single type of sensory input.

Specifically, therapists should focus on using the above research and more along with the principles set forth by AOTA's Choosing Wisely initiative, which cites several best practice recommendations for occupational therapists across all settings. One such recommendation is that therapists should not provide sensory-based interventions to patients who do not have documented sensory processing or integration concerns. This emphasizes the importance of providing interventions that are maximally beneficial to the patient while also preserving the integrity of sensory-based interventions for appropriate patients. Another piece of guidance that AOTA identified is that therapists should not provide non-purposeful intervention activities. Each of the aforementioned sensory activities can be considered non-purposeful unless they are paired with appropriate functional tasks that address the patient's deficits. The same goes for any other type of activity that does not have a functional component.

As part of Choosing Wisely, AOTA also states therapists should not blindly offer interventions for individuals with ASD that aim to eliminate or reduce repetitive behaviors. Therapists who do address repetitive behaviors should ensure they grasp how the behavior functionally plays a part in the person's life along with other environmental and personal factors related to the behaviors. In this sense, therapists may desire to better manage such behaviors to improve a patient's functional performance, but they will likely not be successful unless they take a look at the bigger picture.

Lastly, therapists must be sure to isolate as many variables as possible when using sensory-based interventions in order to effectively gauge the impact they have on a patient. When therapists do this with evidence-based interventions, they are likely to see the most realistic results and can adjust their plan of care accordingly, if necessary.

There are a range of considerations providers must be aware of when adding sensory-based interventions to occupational therapy treatment. It may seem daunting, but the best first step is to look toward the research and utilize principles set forth by AOTA when you are in need of guidance.

Section 3 Personal Reflection

How can therapists convey the importance of sensory-based interventions in their therapy documentation? Apart from daily notes, evaluations/re-evaluations, progress notes, and discharge summaries, are there any other types of documentation that can help justify the utility of interventions with a sensory basis?

Section 4: Case Study #1

An occupational therapist working in an outpatient clinic begins treating a 5-year-old boy with ADHD. He was referred to OT due to disruptive behaviors at school and a gradual decline in academic performance due in part to these behaviors. His teachers suspect that sensory concerns may be emerging and are the cause of these behaviors, which include hitting peers and yelling when told to remain seated. Most of the issues seem to be at the start of the day, which is more hectic than the later parts of the day, and ease up as the school day progresses. The teacher begins instructing the parents on sensory techniques to use at home to manage these behaviors. The parents are confused about the methods and the reason they are being told to address them at home. They have brought their concerns to the OT during the child's first visit.

1. What is the best first move for the therapist to make?

2. What information should the therapist relay to the teacher?

3. Would this patient benefit from sensory-based interventions?

Section 5: Case Study #1 Review

This section will review the case studies that were previously presented in each section. Responses will guide the clinician through a discussion of potential answers as well as encourage reflection.

1. What is the best first move for the therapist to make?

   The therapist should look into reported sensory concerns and perform some standardized testing. Ideally, testing should include perspectives from the child's teacher, parent(s), and other important people in the child's life. This will help determine if the child is demonstrating the same concerns outside of school or not. After completing a thorough evaluation, the therapist should then make a determination about whether the child's concerns are sensory in nature and create goals accordingly.

2. What information should the therapist relay to the teacher?

   The OT should inform the teacher about the results of the evaluation and also address the claims and related information the teacher is giving to the parents without any evidence. Regardless of the results of the evaluation, the teacher is not qualified to speak on whether or not the child has sensory concerns and also should not be offering home programs related to these concerns. The therapist should also speak with the parents to share the results of the evaluation and offer their own recommendations while addressing any questions they have.

3. Would this patient benefit from sensory-based interventions?

   Potentially. If the evaluation determines the patient has sensory concerns, the patient may benefit from sensory-based interventions to assist with transitions and improve their level of alertness. For example, proprioception-based interventions can help with body awareness which may help kids keep their bodies to themselves. Therapists can use interventions such as weighted lap pads or weighted backpacks along with exercise breaks during sessions and throughout the school day. If these sensory interventions are not effective, the therapist should look into other strategies since there is an increased likelihood the child's concerns are related to ADHD.

Section 6: Case Study #2

A 10-year-old female has recently begun school-based OT after being diagnosed with SPD. The child's teacher and mother both report that the student often slouches in her chair and holds her pencil with a fisted grasp. When writing, the student often rips the page due to pressing too hard with her utensil and mom reports she also frequently rips the pages of her notebooks and textbooks when turning them. The student reports difficulty turning only one page at a time. The student reports particular difficulty with writing, stating that it's very difficult for her to sit down and write for long periods of time. After working with the student for a short time, the OT sees that the student has difficulty with traditional writing tasks longer than 2 minutes. This makes it quite difficult to finish coursework in a timely manner and is beginning to impact her academic performance, as she usually turns in her homework assignments late. The student also reports enjoying crafting but has difficulty holding the scissors (both adult and children's) for long enough to get things done on her own.

1. What sensory-based concerns is this child likely to have?
2. Would this student benefit from sensory-based interventions?
3. If so, what type of interventions should the therapist use with this student?

Section 7: Case Study #2 Review

This section will review the case studies that were previously presented in each section. Responses will guide the clinician through a discussion of potential answers as well as encourage reflection.

1. What sensory-based concerns is this child likely to have?

   Based on the child's seated posture, she likely has difficulty processing proprioceptive input, leading to poor body awareness. The child's fisted grasp can be due to a combination of weakness and difficulty with force modulation, as can the child's issues with ripping pages and pressing too hard when writing.

2. Would this student benefit from sensory-based interventions?

   Due to having a diagnosis of SPD, this child most likely would benefit from sensory-based interventions. Because of the student's presenting problems, she should receive interventions that focus on sensory concerns as they pertain to fine motor skills. However, the therapist should be sure to complete an evaluation focused on assessing the student's sensory function before providing any information or creating goals.

3. If so, what type of interventions should the therapist use with this student?

   Based on the above information, the therapist should incorporate sensory-interventions focused on offering proprioception and force modulation. The therapist has reviewed the evidence and is aware that exercise is one of the most effective mediums for high-functioning individuals to access greater proprioceptive input. Some examples of proprioceptive activities include exercise according to the student's preference. The therapist can trial yoga, stretching, animal poses, wall push-ups, jump rope, and a range of other exercises to encourage the student to get sufficient proprioceptive input. Based on the results, the therapist can form these into a home program for regular completion. To address force modulation, the therapist can add another layer to proprioceptive activities. For example, tossing various-sized bean bags and adjusting one's throwing accordingly, using appropriate amounts of glue during crafting activities, peeling stickers, and using a paintbrush.

   These interventions should be supplemented with real-time practice of fine motor tasks such as writing (with a focus on pencil grasp, legibility, and endurance) and paper-based crafting (with a focus on scissors grasp, endurance, and quality of cutting performance). The therapist can start crafting projects with paper and then grade the task up by using thicker paper and eventually other materials to continue strengthening the child's fine motor skills. The therapist should ideally use multi-sensory techniques for writing practice such as a dry erase board, chalkboard, painting, using gel pens, and writing on various-textured surfaces and papers. The variety of options will attend to the student's sensory needs while also assisting in building her writing skills.

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