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Content

CHAPTER I

Investigation of Health Status in Mothers of Children with Cerebral Palsy and Autism: A Comparison on Cognitive Functions, Pain, Physical Activity and Hopelessness

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1.INTRODUCTION

Children with special needs are children who experience significant problems in motor, cognitive, emotional and social skills and face different developmental challenges (McPherson et al., 1998). Caring for these children profoundly affects not only their lives, but also the lives of their families. Mothers, in parti[3]cular, are more physically, emotionally and socially burdened as they assume primary responsibility for the care of their children (Geuze & Goossensen, 2019). The health status of mothers has a critical impact

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not only on their own well-being, but also on the quality of life of their children. Mothers with children with special needs face various challenges in caring for their children, which can directly affect their physical and emotional health. These mothers have to strike a balance where they have to devote more time, energy and effort to meet the special needs of their children, while taking care of their own health (Brekke & Alecu, 2023; Leung & Li-Tsang, 2003).

Cerebral palsy (CP) and autism spectrum disorder (ASD) are two conditions that are frequently encountered among children with special needs and present with different symptoms. CP is a disorder that particularly affects motor functions and is characterized by muscle stiffness, spasticity and limitation of movement. This condition makes it difficult for children to perform activities of daily living independently and often results in the need for intensive physical care support from their mothers (Craig et al., 2019). ASD presents with symptoms such as difficulties in social communication and interaction, limited and repetitive behaviors, and sensory sensitivity. Managing the behavior and supporting the social skills of these children requires intense emotional and intellectual effort on the part of mothers (Lai et al., 2014). Both disorders can be associated with additional health problems in children (e.g. musculoskeletal deformities in CP, sensory integration disorders in ASD), further increasing the burden of care. The aim of this study was to determine the similarities and differences in the physical, psychological and social health status of mothers with children with CP and ASD. The data to be obtained will guide the development of customized support programs for mothers.

2.METHOD

The sample group of this study consisted of mothers of children with special needs who participated in a physiotherapy program at a special education and rehabilitation center in Kırıkkale. All mothers were informed about the study and informed written consent was obtained. Approval for the study was obtained from Kırıkkale University Non-Interventional Research Ethics Committee with decision number 2022.09.15.

The inclusion criteria were that the participants had to have a child with special needs, be between the ages of 18-50, be the primary caregiver of the child, and live in the same household with the child with special needs. Exclusion criteria were that they had chronic neurologic or orthopedic disease, a history of musculoskeletal surgery, and a history of severe or chronic psychosocial disorders before the birth of the child.

2.1. Outcome Measures

In our study, cognitive status, pain severity, hopelessness and physical activity levels of mothers with children with special needs were evaluated in addition to demographic and sociocultural characteristics.

2.1.1. Montreal Cognitive Assessment (MoCA)

Developed by Nasreddine et al. (Nasreddine et al., 2005), the MoCA is designed to assess various stages of cognitive impairment. The scale includes items that evaluate attention and concentration, executive functions, memory, language, visual and spatial skills, abstract thinking, calculation, and orientation. The scale used in the study was found to be valid and reliable for Turkish society.

2.1.2. Beck Hopelessness Scale (BHS)

This 20-item questionnaire assesses hopelessness by measuring participants' negative expectations about future events. The response format of the scale is true or false. BHS scores can range from 0 to 20 (Beck et al., 1974). The adaptation of the scale for the Turkish population was conducted by Durak et al. (Durak & Palabıyıkoğlu, 1994).

2.1.3. International Physical Activity Questionnaire—Short Form (IPAQ-SF)

The scale consists of 7 questions and queries about walking and sitting times, in addition to severe and moderate-intensity physical activities performed in the last 7 days. However, sitting time is not considered in the calculation. Information on days and hours related to the type of physical activity performed is obtained. In the calculation, the entered frequency (days), entered duration data (minutes), and specific metabolic equivalent (MET) values for the activity are multiplied to obtain a score in MET minutes/week (Saglam et al., 2010).

2.1.4. Visual Analog Scale (VAS)

Participants were instructed to mark their level of pain experienced over the past week on a 100 mm line, where 0 indicates no pain and 100 indicates unbearable pain (Boonstra et al., 2014).

2.2. Statistical Analysis

All analyses were performed with SPSS for Mac, Version 26.0 (SPSS Inc., Chicago, Illinois). The normal distribution was confirmed using the Kolmogorov-Smirnov test. Continuous data were presented as mean (SD) and categorical data as numbers and percentages. Since the normal distribution assumption was satisfied, an independent samples t-test was used to compare the means between groups. Statistical significance was set at 0.05.

3. RESULTS

Our study included 90 mothers of children with special needs, 45 with CP and 45 with ASD. Demographic and sociocultural information of the mothers are given in Table 1.

Table 1. *Demographic Characteristics of Mothers of Children with Cerebral Palsy and Autism Spectrum Disorders*

	Mothers of Cerebral Palsi Children		**Mothers of Children with Autism**	
	Mean	**SD**	**Mean**	**SD**
Age (year)	38.76	10.03	38.67	6.85
Number of children	2.29	0.97	2.40	1.21
	n	**%**	**n**	**%**
Marital Status				
Single	28	62,2	11	24,4
Married	10	22,2	26	57,8
Divorced	2	15,5	8	17,8
Education status				
Primary school graduate	19	42,4	15	37,6
Middle school graduate	10	22,2	16	35,6
High school graduate	15	33,2	10	22,2
University graduates	1	2,2	2	4,4

Abbrevations: SD= Standard Deviation, n= Number of Mothers

Our results showed that there was no significant difference between the cognitive performance of mothers with CP and mothers with children with autism ($p = 0.553$). Both groups showed similar MOCA scores (CP: 22.6; Autism: 22.0). A statistically significant difference was observed in hopelessness levels and mothers with children with autism scored higher on the Beck Hopelessness Scale ($p = 0.020$). The mean Beck Hopelessness Scale score of mothers with children with autism was 10.6, while the mean score of mothers with children with CP was 8.1. Physical activity levels were significantly higher in mothers with children with autism compared to mothers with children with CP ($p = 0.041$). The mean of mothers with children with autism was 1502, while the mean of mothers with children with CP was 886.2. There was no statistically significant difference between the two groups in terms of pain intensity (p =

0.379). The mean of mothers with autism was 5.0, while the mean of mothers with CP was 5.4.

Table 2. *Comparison of Pain, Cognitive Function, Physical Activity, and Hopelessness Scores Between Mothers of Children with Cerebral Palsy and Autism*

	Mothers of Cerebral Palsi Children		**Mothers of Children with Autism**		
	Mean	**SD**	**Mean**	**SD**	**p**
MoCA (0-30 puan)	22,6	4,4	22,0	4,7	0,553
BHS (0-20 puan)	8,1	5,8	10,6	4,0	**0,020**
IPAC	886,2	785,3	1502,0	1825,7	**0,041**
VAS (0-10)	5,4	1,9	5,0	1,8	0.379

Abbrevations: SD= Standard Deviation, MoCA=Montreal Cognitive Assessment, BHS=Beck Hopelessness Scale, IPAC= International Physical Activity Questionnaire-Short Form, VAS= Visual Analog Scale.

4. DISCUSSION

This study aims to compare the cognitive status, hopelessness levels, physical activity levels and pain intensity of mothers with children with cerebral palsy and autism spectrum disorders. According to the findings of our study, the cognitive status and pain intensity of the mothers were similar. The physical activity levels of mothers of children with serebral palsy were lower than those of mothers of children with autism spectrum disorders. In addition, the hopelessness level of mothers with autism spectrum disorders was higher than that of mothers with serebral palsy.

Cognition is multifactorial, ranging from genetic characteristics to environmental factors (Tucker-Drob et al., 2013). The literature reveals that mothers of children with special needs may experience difficulties in executive functions such as attention and planning, but these difficulties are affected by many factors such as age, education level, socioeconomic status and stress level (Pardo-Salamanca et al., 2024). For example, it has been reported that chronic stress may lead to impairment in executive functions, whereas social support mechanisms may provide protective effects on cognitive functions (Girotti et al., 2018). The cognition score of both groups in our study was mildly low. However, there was no statistically significant difference between each group.

In the literature, physical and ergonomic burdens of mothers with children with special needs have been frequently emphasized (Green, 2007; Sevgi & Ayran, 2024). The literature shows that musculoskeletal disorders are common in these mothers, often causing pain in the back, neck, shoulders and lower back (Kavlak et al., 2015; Tonga & Düger, 2008). In addition to ergonomic factors and physical loads, it has been emphasized that psychosocial loads may also contribute to physical pain. He stated that chronic stress may exacerbate physical discomfort by increasing muscle tension and pain perception (Timmers et al., 2019). In our study, no statistically significant difference was found between the pain levels of both groups of mothers. This suggested that both groups of mothers were exposed to similar physical strain during daily care activities. However, the pain level of both groups of mothers was at level 5 and higher than the age groups.

As a result of our study, a statistically significant difference was found between mothers with children with ASD and CP in terms of hopelessness levels. Mothers with children with ASD had higher levels of hopelessness. Behavioral difficulties, communication disorders and social interaction deficits of children with ASD can make care processes quite complex. For example, children with ASD may be hypersensitive to changes in routine and exhibit unpredictable behaviors (Tian et al., 2022). This can create a constant source of emotional stress for mothers and increase their levels of hopelessness. The needs of children with CP are generally more physical. Therefore, these needs are more concrete and manageable (Patel et al., 2020). Behavioral differences of children with ASD are often misunderstood and mothers may experience more social isolation as a result (Bi et al., 2022). Inadequate social awareness of autism may lead to negative interpretations of the behaviors of children with ASD by the environment, and this situation causes mothers to feel more judged in society (Bi et al., 2022; Weiss et al., 2021). This can be considered as an important factor that increases the hopelessness levels of mothers with children with ASD. On the other hand, the perception of disability for children with CP can generally be considered more acceptable. Social awareness of physical disabilities is more prevalent in the care of children with CP, which may increase mothers' chances of receiving social support (Kendrick-Allwood et al., 2024; Ostojic et al., 2024). As a result, it can be said that mothers with children with autism have higher levels of hopelessness, care processes related to autism are more complex and social support is more inadequate.

The findings obtained in our study reveal that there are significant differences between the physical activity levels of mothers with children with ASD and CP. The need for a more dynamic approach to the care of children with ASD may lead mothers to engage in more physical activity, whereas the more static nature of the care of children with CP leads mothers to experience their physical burden in different ways (Esentürk & YARIMKAYA, 2021; Rassafiani et al., 2012). As the symptoms of children with ASD are often associated with communication difficulties and behavioral problems (Papadopoulos, 2021), it may lead mothers to adopt a more active lifestyle that requires them to interact with their children. However, children with CP have greater physical rehabilitation and patient care needs due to musculoskeletal problems (Yalcinkaya et al., 2014), which may explain why mothers adopt a more static approach to care. These differences lead to different experiences of care burden and stress for mothers in both groups.

5. CONCLUSION

In our study, cognitive status and pain levels of mothers with children diagnosed with autism spectrum disorder and cerebral palsy were similar, but they differed in terms of physical activity levels and hopelessness levels. Physical activity levels of mothers of children with cerebral palsy were lower than those of mothers of children with autism spectrum disorder, and hopelessness levels were significantly higher in mothers of children with autism spectrum disorder. These findings suggest that mothers of children with ASD and CP face different challenges and that support mechanisms should be designed in accordance with these differences.

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CHAPTER II

Artıfıcıal Intellıgence Use In Stroke

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I. **Introduction**

A. Global impact of stroke on health

Stroke is a significant global health burden with substantial impacts on mortality, morbidity, and long-term disability. It is a leading cause of loss of health in late adulthood, and the burden is projected to increase, particularly in terms of morbidity and disability (Kalache & Aboderin, 1995; Leonov et al., 2024). The Global Burden of Disease 2013 study estimates highlight the immense and rapidly increasing burden of stroke, which threatens worldwide sustainability (Feigin et al., 2016).

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B. Importance of personalized approaches in stroke management

Personalized approaches to stroke management are increasingly recognized as crucial for improving patient outcomes and optimizing care. Machine learning techniques have emerged as promising tools in stroke medicine, enabling efficient analysis of large-scale datasets and facilitating personalized and precision medicine approaches (Daidone, Ferrantelli, & Tuttolomondo, 2024). These techniques have demonstrated remarkable accuracy in imaging analysis, the diagnosis of stroke subtypes, risk stratification, guiding medical treatment, and predicting patient prognosis.

The importance of personalized approaches is further emphasized by the potential of artificial intelligence (AI) to compute single-patient predictions in stroke outcome research across acute, subacute, and chronic stages (Bonkhoff & Grefkes, 2022). This individualized approach considers various data types, including demographic, clinical, electrophysiological, and imaging data, to enhance favorable outcomes after stroke.

Interestingly, biomarkers, such as copeptin, have shown promising prognostic potential in stroke patients, highlighting the added value of individualized biomarker evaluation in stroke management (Karatzetzou et al., 2023). The emergence of the neurovascular team concept, mirroring the multidisciplinary Heart Team, embraces diverse specializations and personalized tailored medicine approaches to individual patient needs (Musialek et al., 2023).

C. Limitations of traditional methods

Conventional stroke rehabilitation approaches often lack personalization and fail to address heterogeneity among stroke patients. This has contributed to the failure of many major stroke clinical trials over the past few decades, suggesting the need for more tailored treatment strategies (Hatem et al., 2016; S. J. Kim, Moon, & Bang, 2013). Resource limitations frequently prevent early rehabilitation interventions that are crucial for optimal recovery.

Many stroke survivors lack access to specialized rehabilitation services during the critical early post-stroke period owing to constraints in healthcare systems (Pugliese et al., 2019).

Traditional assessment methods for stroke rehabilitation can be subjective and may not capture subtle improvements in motor function (Su, Hu, Wu, Shang, & Luo, 2023). While integrated care pathways show promise in improving quality and reducing costs in stroke management, evidence supporting their effectiveness remains weak and uncertain (Sulch & Kalra, 2000). This highlights the need for more objective and sensitive evaluation tools to guide treatment and to measure outcomes. Further research is needed to validate these approaches before their widespread implementation.

D. Potential of AI in stroke management

AI has shown significant potential in revolutionizing stroke management and offering improved diagnosis, treatment, and patient outcomes. AI-based care coordination platforms have demonstrated the ability to reduce door-to-puncture time and enhance the efficiency of acute stroke care. In one study, the utilization of an AI platform resulted in a significant decrease of 39.5 minutes in the time to neurointerventionalist (NIR) contact, increased number of patients taken for intervention, and lowered door-to-needle times for thrombolytics (Sevilis et al., 2023).

Interestingly, AI applications in stroke management extend beyond acute-care settings. A hybrid AI system combining CNN, GMDH, and LSTM deep learning models was developed for stroke prediction and diagnosis, achieving high accuracy rates of up to 98% for stroke diagnosis and 99% for EMG signal prediction. This mobile AI smart hospital platform architecture for stroke prediction and emergencies represents an innovative approach to connected health, potentially enabling early detection and a rapid response to stroke events (Elbagoury et al., 2023).

By reducing treatment delays, enhancing diagnostic accuracy, and enabling personalized care, AI technologies can contribute to better outcomes in stroke patients. However, as with all

AI applications in healthcare, careful consideration must be given to ethical implications, data privacy, and the need for robust validation before widespread clinical implementation (Udegbe, Ebulue, Ebulue, & Ekesiobi, 2024).

II. Early Diagnosis and Treatment Planning

A. Role of AI in early stroke detection

AI plays a crucial role in early stroke detection and offers significant improvements in diagnosis, triage, and treatment planning. In acute stroke imaging, AI applications cover various aspects of the stroke treatment paradigm, including infarct or hemorrhage detection, segmentation, classification, large-vessel occlusion (LVO) detection, and Alberta Stroke Program Early CT Score (ASPECTS) grading. Convolutional neural networks (CNNs), a type of deep learning algorithm, are particularly promising for performing these imaging-based tasks efficiently and accurately (Y. Y. Wang et al., 2024; Yedavalli, Tong, Martin, Yeom, & Forkert, 2021). For example, CNNs have demonstrated greater sensitivity (85%) compared to random forest learning (68%) in image feature detection for LVO strokes (Murray, Unberath, Hager, & Hui, 2020).

By enhancing the speed and accuracy of diagnosis, AI tools can significantly reduce the time to treatment and potentially improve patient outcomes. However, it is important to note that while AI shows great promise, ongoing research and standardization of performance assessments are necessary to fully realize its potential in clinical practice. As AI continues to evolve, it is likely to play an increasingly important role in optimizing stroke care and improving patient outcomes (Murray et al., 2020).

B. Deep learning algorithms for imaging analysis

Deep learning algorithms have shown significant promise for stroke imaging analysis, particularly for lesion detection and segmentation. Convolutional Neural Networks (CNNs) and Fully Convolutional Networks (FCNs) are two key deep architectures employed for these tasks (Karthik, Menaka, Johnson, & Anand, 2020).

LeNet and SegNet models have been used effectively for brain stroke diagnosis from MRI. LeNet achieved 96-97% accuracy in classifying normal and abnormal images, whereas SegNet reached 85-87% accuracy in segmenting abnormal regions (Gaidhani, Rajamenakshi, & Sonavane, 2019). Other foundational architectures for medical image segmentation include CNN-based and transformer-based models, which have been adapted for stroke lesion segmentation across multiple datasets, such as ATLAS, ISLES, and AISD (Luo et al., 2024).

Deep-learning algorithms have demonstrated significant capabilities in stroke imaging analysis, particularly in lesion detection, segmentation, and classification. As the field progresses, researchers are not only focusing on improving accuracy, but also addressing challenges related to data privacy, security, and availability. The integration of these advanced techniques with clinical information and electronic medical records holds promise for enhancing acute stroke management and decision-making (Chavva et al., 2022)

C. AI-based risk prediction models

AI-based risk prediction models for stroke have shown significant potential in improving early detection and prevention strategies. These models leverage various data sources and advanced machine-learning techniques to predict stroke risk with high accuracy.

Several studies have demonstrated the effectiveness of AI in predicting strokes. For instance, a model using laboratory test data achieved impressive results, with the random forest algorithm reaching an accuracy of 0.96 and sensitivity of 0.97 (Alanazi Luo, 2021). This approach is an easy-to-use and highly accurate predictive tool. In the context of acute coronary syndrome (ACS), machine learning techniques have shown promise for identifying high-risk patients and predicting adverse events and mortality (. Wang, Zu, Chen, Yang, & Ahmed, 2021).

Some studies have explored novel approaches to stroke prediction. A mobile AI smart hospital platform architecture for stroke prediction and emergencies has been proposed that integrates (Internet of Medical Things) with AI techniques. This system uses a hybrid of the GMDH and LSTM deep learning models, achieving an average accuracy of 99% for EMG signal prediction in stroke scenarios. These interventions can target multiple risk factors such as nutrition, weight loss, physical activity, sleep hygiene, blood pressure, dyslipidemia, smoking, alcohol consumption, and mental health (Elbagoury et al., 2023).

D. Preventive interventions guided by AI

AI-guided preventive interventions for stroke have shown promising potential in various aspects of cardiovascular health management. AI integration into preventive cardiology may introduce novel treatment interventions and AI-centered clinician assistive tools to reduce the risk of cardiovascular disease (CVD), including stroke (El Sherbini et al., 2024).

AI-enabled models have demonstrated reasonable accuracy in discriminating the risk of atrial fibrillation (AF), a major risk factor for stroke (Pipilas, Friedman, & Khurshid, 2023). By identifying individuals at a higher risk for AF, these models may improve the efficiency of preventive efforts, including screening and risk factor modification. Additionally, global strategies such as effective tobacco control, adequate nutrition, and the development of healthy cities are crucial for primordial prevention, while polypill strategies and mobile technology (mHealth) interventions show promise in primary stroke prevention (Pandian et al., 2018). The integration of AI into these preventive measures could potentially enhance their effectiveness and reach, ultimately reducing the global burden of stroke.

III. AI in Stroke Rehabilitation

A. Contribution to motor and cognitive skill recovery

Deep learning models inspired by the brain's architecture have been used to understand how convolutional layers and recurrent connections in the cerebral cortex control important functions, such as visual processing, memory, and motor control (Macpherson et al., 2021). This understanding can be used to develop targeted interventions for motor and cognitive skill recovery. AI's ability of AI to process and analyze large neuroscience datasets is also valuable in understanding brain network changes associated with psychopathologies, potentially leading to new treatment approaches (Macpherson et al., 2021). While AI contributes to understanding and treating cognitive and motor skills, physical activities such as football training have been shown to improve both motor and cognitive performance in children (Alesi et al., 2015).

B. AI-assisted movement analysis systems

AI-assisted movement analysis systems have shown promising results in the fields of clinical medicine and rehabilitation. A study evaluating the use of AI-assisted markerless motion capture software, specifically OpenPose, demonstrated its effectiveness in analyzing the hip, knee, and ankle joint angles during treadmill walking. In addition, the software's ability to recognize movement in individuals using ankle foot orthoses or crutches addresses concerns about its applicability to patients with lower limb dysfunction. The findings suggest that OpenPose can adequately substitute for conventional passive marker motion capture in both normal and abnormal gait scenarios, including those involving orthoses or crutches (Takeda, Yamada, & Onodera, 2021).

AI-assisted markerless motion capture systems, such as OpenPose, offer a promising alternative to traditional motion analysis methods in clinical settings. These systems can reduce the complexity and cost associated with conventional passive marker motion capture (Takeda et al., 2021) without compromising the recognition accuracy (Takeda et al., 2020). As AI technologies continue to advance, we expect further improvements in movement analysis systems, potentially leading to more efficient and accessible rehabilitation practices.

C. Robotic rehabilitation devices and virtual reality (VR) applications

Robotic rehabilitation devices and virtual reality (VR) applications have shown significant potential for supporting neuroplasticity and enhancing motor recovery after stroke. These technologies offer intensive, repetitive, and engaging therapies that can stimulate neural reorganization and promote functional improvement (W.-S. Kim et al., 2020; Rajashekar, Boyer, Larkin-Kaiser, & Dukelow, 2024).

VR environments provide interactive and immersive experiences that can enhance neuroplasticity by offering tasks of various difficulty levels, augmented real-time feedback, and safe simulations of real-world activities (W.-S. Kim et al., 2020). When combined with robotic devices, VR can create personalized assistive therapy experiences that motivate and assist users in performing rehabilitative movements (Elor, Lessard, Teodorescu, & Kurniawan, 2019). For instance, the PERCRO L-Exos system, a force-feedback exoskeleton integrated with VR, demonstrated improvements in Fugl-Meyer scores, Ashworth scale, and ranges of motion in chronic stroke patients (Frisoli, Bergamasco, Carboncini, & Rossi, 2009).

The synergistic use of EMG-controlled VR interfaces offers a novel approach for testing and manipulating neural control of arm movements. This method allows tailored assistance based on individual changes in synergistic organization, potentially opening up new possibilities for rehabilitation (Berger & d'Avella, 2017). Additionally, the combination of VR and soft robotics, as seen in Project Butterfly, shows promise in creating engaging and accurate physical therapy experiences (Elor et al., 2019).

Robotic rehabilitation devices and virtual reality (VR) applications have shown promising results in accelerating motor function development in patients with various neurological conditions, particularly in stroke survivors. These technologies offer interactive, engaging, and customizable rehabilitation experiences that can enhance patient motivation and potentially improve outcomes compared to traditional therapy methods (Covaciu, Pisla, & Iordan, 2021; Ma et al., 2007).

VR-based systems, often combined with robotic devices, provide realistic and physically based simulations that allow patients to practice functional tasks in adaptive environments. These systems can be tailored to individual patient abilities and performance with features such as scalable gravity and force feedback (Ma et al., 2007). The integration of VR with robotic rehabilitation has demonstrated improvements in motor function and cognitive abilities, including attention and executive function (Fusco et al., 2022; Torrisi et al., 2021).

In conclusion, the integration of robotic devices and VR applications in rehabilitation provides a powerful tool to support the acceleration of motor function development and neuroplasticity. These technologies offer the ability to create intensive, repetitive, and motivating therapy experiences that can be easily graded and documented (Sveistrup 2004).

D. Wearable AI Technologies

Wearable AI technologies have shown promising application in stroke rehabilitation and management. These technologies combine wearable devices with AI to provide innovative solutions for patients with stroke. Flexible technology (FT) is increasingly being used in stroke rehabilitation systems, allowing the development of compact and lightweight wearable devices that stroke survivors can use for long-term activities. These systems primarily involve biosignal acquisition units, rehabilitation devices, and assistive systems. Electroencephalography (EEG) and electromyography (EMG) are commonly used to acquire biosignals. Rehabilitation and assistive systems often incorporate functional electrical stimulation and robotics units such as exoskeletons and orthoses (Khan, Saibene, Das, Brunner, & Puthusserypady, 2021).

Wearable sensors have the potential to objectively assess and monitor stroke patients, both inside and outside the clinical environment. This enables a more detailed evaluation of impairments and allows for the individualization of rehabilitation therapies (Maceira-Elvira, Popa, Schmid, & Hummel, 2019). These sensors can be used to collect a broad spectrum of data, including physiological variables, positional data, and kinematic data, which can be processed and analyzed by AI systems to improve performance and guide rehabilitation strategies (Chidambaram et al., 2022).

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IV. Brain-Computer Interfaces (BCI)

A. Innovative application of AI in stroke management

AI is revolutionizing stroke management and offering innovative applications in various aspects of care. In acute stroke settings, AI techniques have been applied to decipher data from stroke imaging, demonstrating promising results in improving diagnostic accuracy and quality of patient care (Lee, Kim, Kim, & Kang, 2017). AI-enabled technologies, particularly those using convolutional neural networks (CNNs), can identify abnormal brain images and perform comparably to neuroradiologists in diagnosing stroke. These technologies have been shown to improve clinical workflows, such as reducing the time from scan acquisition to reading, and enhancing patient outcomes, including reducing the number of days spent in neurological ICU (Chandrabhatla et al., 2023).

AI applications in stroke management span multiple areas, including automated assessment, therapy, and personalized assistive systems. In aphasia rehabilitation, AI has progressed from prototypes and simulations to include supervised and unsupervised machine learning, natural language processing, fuzzy rules, and genetic programming. These advancements offer potential for patient-centered, customized rehabilitation and enhanced self-management for individuals with aphasia (Adikari, Hernandez, Alahakoon, Rose, & Pierce, 2024). In prehospital diagnosis, AI can assist in rapid triage and decision making, potentially reducing the time to treatment (Zeleňák et al., 2021). Moreover, AI-enabled technologies have been developed to promote post-stroke neurological and functional recovery using neuromodulation techniques (Chandrabhatla et al., 2023).

While most AI applications focus on diagnosis and treatment, there is considerable scope for aligning AI technology with aphasia rehabilitation to empower patient-centered, customized rehabilitation, and enhanced self-management. These advancements offer the potential for patient-centered, customized rehabilitation and enhanced self-management for individuals with aphasia (Adikari et al., 2024). Additionally, AI and robotics are being implemented at every level of stroke care, from prehospital diagnosis to rehabilitation, with the potential for remote control of robotic systems through improved internet networks like 5G (Zeleňák et al., 2021).

B. Thought-controlled devices for motor skill recovery in paralyzed individuals

Brain-machine interfaces (BMIs) or brain-computer interfaces (BCIs) are emerging as promising technologies for motor skill recovery in paralyzed individuals. These systems translate brain activity into control signals for external devices, enabling patients with severe motor disabilities to interact with their environment (Chaudhary, Birbaumer, & Curado, 2015; Chaudhary, Birbaumer, & Ramos-Murguialday, 2016). BMIs have shown potential in two key areas: assisting communication in completely paralyzed patients and facilitating motor recovery after stroke or spinal cord injury (Chaudhary et al., 2016; Colucci et al., 2022).

BMIs using electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) have enabled locked-in patients to communicate, even those with complete paralysis (Chaudhary et al., 2015; Chaudhary et al., 2016). In motor rehabilitation, BMI-controlled exoskeletons provide simultaneous activation of the motor cortical output and sensory feedback, promoting neural plasticity and functional recovery (Colucci et al., 2022; Ushiba & Soekadar, 2016). A randomized controlled study demonstrated that BCI-supported motor imagery training led to better functional outcomes in patients with subacute stroke than motor imagery alone (Pichiorri et al., 2015).

Recent advances in BMI technology, including the use of chronic electrocorticography implants, have improved long-term reliability and reduced daily recalibration requirements (Silversmith et al., 2021). Additionally, hybrid systems combining fNIRS and EEG show promise in enhancing the spatial and temporal resolution for motor rehabilitation applications (Chen et al., 2023). As BMI technology continues to evolve, its integration into clinical care and existing therapy plans is crucial for widespread adoption and further improvement of personalized treatment strategies for paralyzed individuals (Colucci et al., 2022).

V. Challenges and Future Directions

AI has shown significant potential in revolutionizing stroke care; however, its widespread adoption faces several challenges. In acute and intensive care settings, AI applications range from early warning systems to treatment suggestions, enhancing medical imaging interpretation, and streamlining clinical workflow. However, the integration of AI in stroke management is hindered by ethical, legal, technical, organizational, and validation challenges (Biesheuvel, Dongelmans, & Elbers, 2024).

One of the primary concerns in AI implementation for stroke care is the lack of explainability of deep learning models. The absence of clear explanations for AI-driven decisions poses a significant drawback in critical decision-making processes, particularly in precision medicine (Choo and Liu 2018). This issue is further compounded by the need for transparency and control over AI's internal processes of AI, which areis crucial for building trust and ensuring accountability in stroke management (Choo & Liu, 2018; Hosain, Jim, Mridha, & Kabir, 2024).

In the future, several directions will emerge to advance AI in stroke care. Developing multimodal AI systems that can process varied biomedical data for comprehensive decision support is promising (Biesheuvel et al., 2024). Efforts are being made to make deep learning models more interpretable and controllable, which is essential for their integration into clinical practice (Choo and Liu, 2018). Additionally, the advancement of AI-powered surgical navigation and the exploration of federated learning approaches could significantly enhance stroke treatment outcomes (Singh, 2024). As these challenges are addressed, AI has the potential to transform the landscape of stroke care by offering more personalized, effective, and efficient management strategies.

VI. Conclusion

AI is transforming the landscape of stroke care by enhancing its early detection, treatment planning, rehabilitation, and long-term management. Its integration into stroke management offers unprecedented opportunities to improve patient outcomes through personalized approaches, real-time decision making, and innovative therapeutic interventions. From AI-driven imaging tools that accelerate diagnosis to brain-computer interfaces enabling motor recovery, these technologies address many limitations of traditional methods and pave the way for a more individualized and precise care paradigm.

However, the full potential of AI in stroke management is yet to be realized owing to several challenges, including the need for explainability, ethical considerations, and robust clinical validation. Overcoming these hurdles will require multidisciplinary collaboration, advancements in AI model transparency, and standardized protocols to ensure safe and effective implementation.

Future directions include the development of multimodal AI systems capable of processing diverse biomedical data, application of federated learning for secure and scalable AI training, and integration of AI with emerging technologies such as 5G networks and robotic systems. As these innovations evolve, AI is poised to become an integral part of stroke care, offering a transformative approach that benefits both patients and health care providers.

By leveraging AI's capabilities in diagnosis, rehabilitation, and prevention, we can not only improve the quality of life of stroke survivors, but also significantly reduce the global burden of this debilitating condition. Continued investment in research, clinical trials, and ethical frameworks is critical to ensuring that AI achieves its promise in stroke management, ultimately leading to a more sustainable and effective healthcare system.

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CHAPTER III

Reaction Time and Physical Decline: Insights from Neurological Disorders in Older Adults

Fatma Kübra Çekok[1]

INTRODUCTİON

Aging, a multifaceted process characterized by progressive decline in physiological function, is influenced by a complex interplay of genetic, epigenetic, and environmental factors (López-Otín, Blasco, Partridge, Serrano, & Kroemer, 2013). This decline manifests as a reduction in cellular repair mechanisms, accumulation of cellular damage, and alterations in the body's homeostatic systems. The resulting phenotypic changes often include sarcopenia, frailty, and increased susceptibility to chronic diseases. Cognitive functions, such as memory, attention, and executive function, also

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undergo age-related decline, which can be exacerbated by conditions such as Alzheimer's disease and vascular dementia (Sweet, 2011)

The aging process is complex and affects both cognitive and motor systems. Reaction time (RT) – the duration between stimulus presentation and reaction — is a well-established metric of sensory-motor integration (Shaw, Joshi, Greenwood, Panda, & Lord, 2010). In older persons, delayed reaction time is a characteristic of diminished functional performance, affecting balance, mobility, and the capacity to execute activities of daily living (ADLs). Comprehending the fundamental principles and clinical significance of RT in this demographic is essential for formulating tailored therapies to alleviate age-related deterioration. Various types of reaction time (RT) exist, with simple RT and choice RT being the most prevalent (Deary, Liewald, & Nissan, 2011) In simple reaction time (RT), one stimulus is presented, and a single response is executed; in choice RT, multiple stimuli are presented, requiring the participant to select the correct response from at least two options(Deary et al., 2011; Kosinski, 2008).

Aging is commonly linked to declines in processing speed, which can impair cognitive efficiency in tasks requiring quick decision-making, problem-solving, and multitasking (Salthouse, 2010). Physiological changes in the brain, such as reduced neural transmission efficiency and white matter deterioration (e.g., demyelination), contribute to this decline. These changes slow the speed at which information travels between brain regions, affecting tasks like driving, decision-making, and social interactions. This decline in processing speed can increase vulnerability to broader cognitive impairments, including dementia (Verhaeghen & Salthouse, 1997).

Reaction time measurements are a commonly used assessment tool to identify health risks and monitor treatment progress in older adults. These measurements are particularly conducted by physiotherapists and other healthcare professionals in individuals with norolojicaland musculoskeletal disorders. Reaction time tests are typically performed using computer-based platforms or sensor technologies, enabling the acquisition of rapid, accurate, and reliable data. Additionally, reaction time measurements can be utilized to assess the effectiveness of physical therapy or exercise programs (Lajoie & Gallagher, 2004; Mendelson, Redfern, Nebes, & Richard Jennings, 2009).In conclusion, reaction time measurement in older adults not only evaluates physical health but also provides valuable information regarding cognitive functions and overall quality of life. These measurements play a critical role in identifying fall risks, guiding treatment processes, and helping older individuals maintain their independence

Parkinson's disease is a progressive neurodegenerative disorder characterized by motor symptoms such as tremor, rigidity, and bradykinesia. It has been demonstrated in the literature that reaction time is impaired in Parkinson's disease. This impairment in cognitive processing speed can significantly impact an individual's ability to perform daily activities and contributes to their overall quality of life (Berry, Nicolson, Foster, Behrmann, & Sagar, 1999). According to the review, Parkinson's disease (PD) affects reaction time performance, with both motor deficits (e.g., bradykinesia) and cognitive impairments (e.g., attention and information processing speed) contributing to delayed responses. The review highlights the role of basal ganglia dysfunction and suggests that reaction time delays may be influenced by motor and non-motor factors, including changes in executive function and sensory processing (Gauntlett-Gilbert & Brown, 1998). Another meta-analysis examines serial reaction time (SRT) performance in Parkinson's disease (PD). It finds significant impairments in SRT tasks, with delayed reaction times compared to healthy controls. Factors such as disease severity, medication status, and cognitive deficits influence these impairments. Motor dysfunctions like bradykinesia and cognitive factors, including executive function and attention, contribute to slower response times. The study highlights the variability in performance, suggesting that SRT tasks are useful for understanding PD-related deficits and monitoring disease progression (Clark, Lum, & Ullman, 2014).

Stroke, a cerebrovascular event resulting in brain damage, can significantly impair cognitive and motor functions, including reaction time (Einstad et al., 2021). Debeljak et al. investigate simple and choice reaction times in healthy adults and stroke patients during simulated driving tasks. The study compares reaction time performance between these two groups, highlighting significant delays in stroke patients. Results suggest that stroke survivors exhibit slower responses, particularly in choice reaction tasks, which could impact their ability to safely drive (Debeljak, Vidmar, Oberstar, & Zupan, 2019).The systematic review by Caires et al. (2021) provides valuable insights into the impact of various intervention protocols on choice reaction time (CRT) in stroke survivors. Stroke often leads to impaired reaction times due to both cognitive and motor dysfunctions. The findings highlight that tailored rehabilitation strategies, including physical therapy and cognitive training, can significantly improve CRT performance. Specifically, therapies focusing on enhancing attention, processing speed, and motor coordination were found to be particularly effective in reducing delays in reaction times. Another review underscores the cognitive ramifications of multiple sclerosis (MS), particularly focusing on impairments in attention, memory, executive function, and processing speed (Calabrese, 2006). These cognitive deficits are attributed to the demyelinating process within the central nervous system, disrupting efficient information processing. The significance of neuropsychological assessments in diagnosing and managing these cognitive impairments is highlighted, as they can significantly impact the quality of life for individuals with MS (Calabrese, 2006).

Significant evidence suggests that older individuals have a reduced reaction time, which is associated with falls. A systematic review has shown that exploring the relationship between executive function, falls, and gait abnormalities in older adults is important. The study highlights the crucial role of executive function, which includes cognitive processes like attention, planning, and problem-solving, in maintaining balance and gait. They found that impairments in executive function are strongly associated with an increased risk of falls and abnormal gait patterns in older adults (Kearney, Harwood, Gladman, Lincoln, & Masud, 2013). It is recommended to implement therapies aimed at enhancing executive function, such as structured cognitive training programs or dual-task exercise regimens. These interventions have the potential to mitigate fall risk and improve gait performance in older adults by targeting underlying cognitive processes, including attention, planning, and problem-solving.

CONCLUSION

In conclusion, impairments in reaction time are a common feature across various neurological and age-related conditions, reflecting a complex interplay between motor and cognitive systems. Conditions such as Parkinson's disease, stroke, multiple sclerosis, and aging share the commonality of slower reaction times, which are influenced by a combination of motor dysfunction, such as bradykinesia or loss of coordination, and cognitive deficits, including impaired attention, processing speed, and executive function. These findings underscore the intricate relationship between structural and functional disruptions in the nervous system and reaction time impairments.

The evidence supports the potential of targeted rehabilitation and intervention strategies to address these impairments. Therapies that integrate cognitive and motor training have shown promise in improving reaction time and associated functional outcomes, leading to enhanced quality of life. These results emphasize the importance of a holistic approach in both research and clinical practice to optimize rehabilitation and support for affected populations.

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CHAPTER IV

Ethıcal Dımensıons Of Usıng Artıfıcıal Intellıgence In Physıotherapy

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1. Introduction

Artificial intelligence (AI) has begun to drive a significant transformation in healthcare services and has emerged as an effective tool, particularly in rehabilitation processes, such as physiotherapy. The rapid advancement of technology has enabled physiotherapists to adopt more objective and data-driven approaches in processes, such as diagnosis, evaluation, and treatment planning. While traditional physiotherapy methods rely on clinician observations, experience, and manual measurements, AI systems

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make these processes faster, more precise, and personalized (Esteva et al., 2019; Topol, 2019).

AI technologies have achieved substantial advancements, particularly in areas such as machine learning, big data analytics, and image processing, facilitating patient-evaluation processes. For instance, AI-powered motion analysis systems can automatically analyze patients' movement patterns to identify postural disorders and motor function deficits. Similarly, by leveraging big data analytics, patients' medical records can be examined to develop more effective and personalized treatment programs. AI-based clinical decision support systems provide physiotherapists with the ability to closely monitor patient progress and promptly intervene when necessary.

However, these technological advancements have raised significant ethical concerns. In the use of AI in physiotherapy, issues such as patient privacy, data security, algorithmic bias, and the human-centered nature of decision-making processes occupy a central place in ethical discussions. The lack of sufficient transparency in the decision-making mechanisms of AI systems undermines the trust in these systems for both physiotherapists and patients. Moreover, protecting patient data remains a critical concern (Morley et al. 2020).

This study aimed to comprehensively examine AI applications in the field of physiotherapy. In addition to exploring the potential benefits of AI, this study will also focus on the ethical dimensions of this technology, discussing how a safe, fair, and human-centered approach can be adopted in physiotherapy practices. By delving into the intersection of AI and physiotherapy, this study will thoroughly examine the new opportunities arising from this convergence and the ethical responsibilities that accompany these advancements.

2. The Intersection of Artificial Intelligence and Physiotherapy

AI stands out in the field of physiotherapy for various applications including clinical decision support systems, robotic rehabilitation, patient evaluation, treatment planning, and remote monitoring. By leveraging machine learning (ML) and deep learning techniques, AI can analyze patient movements quickly and accurately. For instance, posture disorders or movement limitations can be identified using wearable sensors and AI algorithms, allowing for the development of personalized treatment programs (Liao, Hsieh, Lee, Chen, & Wu, 2022).

AI integrated robotic physiotherapy devices play a pivotal role in accelerating motor learning and are particularly significant in neurological rehabilitation. In post-stroke rehabilitation, AI-assisted systems effectively enhance motor functions by providing repetitive and intensive movement training (He, Eguren, Luu, & Contreras-Vidal, 2017).

Additionally, AI-based platforms in remote physiotherapy services enable the monitoring of patients' treatment processes at home and provide detailed data to therapists, facilitating clinical decision-making. This approach has gained prominence, particularly during the COVID-19 pandemic, with the increased adoption of tele-rehabilitation applications (Cowie et al., 2016).

3. Potential Benefits of Using Artificial Intelligence in Physiotherapy

The integration of AI technologies into the field of physiotherapy offers significant advantages such as enhancing the efficiency of patient care, saving time, and improving clinical outcomes. Traditional physiotherapy methods are often limited to direct observations, manual measurements, and experiential evaluations of physiotherapists. However, AI-based systems support faster and more accurate decision making by analyzing far larger and more complex datasets.

3.1. Faster and More Accurate Diagnosis and Assessment

AI plays a crucial role in motion analysis and early detection of musculoskeletal disorders. By utilizing image processing techniques and sensor data, AI provides physiotherapists with precise and objective insights into patients' movement patterns (Zsarnoczky-Dulhazi, Agod, Szarka, Tuza, & Kopper, 2023). For example, gait analysis systems enable the rapid identification of postural disorders, facilitating the creation of tailored treatment plans.

3.2. Personalized Treatment Programs

AI leverages big data analytics and machine learning to design treatment programs that are customized to each individual's needs. These systems analyze factors such as patient age, physical condition, treatment history, and progress data to recommend the most suitable therapeutic approach. As a result, patient adherence improves and recovery times are shortened (Sharma & Chowdhury, 2020).

3.3. Robotic and Automated Rehabilitation

AI-powered robotic rehabilitation systems significantly aid in restoring motor skills, particularly in patients with neurological diseases or orthopedic injuries. These systems ensure that repetitive movements are performed accurately, reducing the workload of therapists and allowing for continuous patient supervision. Robotic-assisted exercises have been found to be highly effective for intensive motor training required for stroke rehabilitation (Masiero, Celia, Rosati, & Armani, 2007).

3.4. Remote Patient Monitoring and Tele-Rehabilitation

The importance of remote healthcare services has significantly increased during the COVID-19 pandemic. AI is utilized in tele-rehabilitation applications to monitor patients' exercise at home and analyze their performance. These systems detect deficiencies in patient movement and provide therapists with detailed reports. This capability offers a significant advantage, particularly for individuals with mobility limitations or those who face difficulties in accessing healthcare facilities (Cowie et al., 2016).

3.5. Clinical Decision Support Systems

AI assists physiotherapists in clinical decision-making processes, enabling reliable and consistent treatment planning. These systems analyze previous patient data to recommend the most suitable therapeutic strategy and guide physiotherapists accordingly.

These advantages underscore the importance of efficient and effective use of AI in physiotherapy. However, it is crucial to ethically evaluate these technological advancements and employ them with a sense of responsibility..

4. The Emergence of Ethical Issues

The integration of AI technologies into healthcare services such as physiotherapy raises ethical concerns. Although AI systems facilitate patient evaluation and treatment processes, their use must remain within ethical boundaries. Key ethical issues in the healthcare applications of AI include patient privacy, data security, human-centered decision-making, algorithmic bias, and accountability (Morley et al., 2020).

4.1. Patient Privacy and Data Security

AI systems require large amounts of patient data for effective functioning. Protecting patient privacy during the collection, processing, and storage of such data is of paramount importance. Misuse or unauthorized access to personal health information poses a threat to patient safety and may result in ethical violations. Strict implementation of data security protocols and obtaining informed consent from patients are essential at this point (Vayena, Blasimme, & Cohen, 2018).

4.2. Algorithmic Bias

AI systems can reflect the biases present in the datasets on which they are trained, leading to skewed decisions. Particularly for different sexes, age groups, and ethnicities, the evaluation and recommendation mechanisms of AI may yield inaccurate or inconsistent results. For example, the limited diversity of datasets used in AI-based motion analysis systems can result in inadequate assessments for certain patient groups, jeopardizing the delivery of equitable healthcare services (Mehrabi, Morstatter, Saxena, Lerman, & Galstyan, 2021).

4.3. The Role of Human Factors and Responsibility

Physiotherapy is a profession rooted in the direct interaction between patients and therapists. The inclusion of AI systems in decision-making processes poses the risk of sidelining human factors. Additionally, the question of accountability for errors made by AI systems is a critical ethical concern. Ensuring that AI is solely used as a supportive tool and that final decisions are always made by qualified physiotherapists is essential for maintaining patient safety (Morley et al., 2020).

4.4. Transparency and Accountability

The lack of transparent information on how AI systems function can foster distrust among patients and health care professionals. Understanding the AI decision-making processes will enhance trust in these systems for both groups. Establishing accountability mechanisms is a critical step toward promoting the ethical use of AI.

4.5. Economic and Social Inequalities

The high costs of AI technologies can limit access to these services for individuals in low-income countries or regions. This may exacerbate the existing inequalities in healthcare and pose ethical issues. Making AI-assisted physiotherapy services accessible and sustainable for everyone is a key ethical objective.

As the role of AI in physiotherapy expands, addressing the ethical issues outlined above requires a multidisciplinary approach that fosters collaboration among healthcare professionals, technology developers, and ethics experts.

5. Ethical Principles and AI Applications in Healthcare

The use of artificial intelligence (AI) technologies in physiotherapy applications must be guided by ethical principles. In healthcare, ethical principles aim to protect patients' safety and rights. The integration of AI should particularly consider core ethical principles, such as autonomy, beneficence, non-maleficence, and justice (Beauchamp & Childress, 1994).

5.1. Autonomy

One of the fundamental ethical principles in healthcare is to ensure that patients are informed and capable of making autonomous decisions about their treatment processes. In applications that utilize AI systems, patients must be informed about how the technology works, what data are used, and the potential risks involved. For instance, explaining that an AI system is used as a decision-support mechanism and obtaining the patient's consent are essential components of ethical responsibility (Vayena et al., 2018).

5.2. Beneficence

AI technologies should be utilized to accelerate patient recovery and enhance the effectiveness of treatment. AI has the potential to provide maximum benefits to patients by enabling accurate diagnoses and personalized treatment programs. For example, robotic rehabilitation devices and AI-supported exercise analysis systems accelerate functional recovery in patients, thereby offering significant advantages (Topol, 2019). However, the inappropriate use of these technologies or faulty algorithms can harm patients.

5.3. Non-Maleficence

The safe use of AI technology is closely linked to the principle of non-maleficence. In AI-assisted evaluation and treatment systems, it is crucial to ensure that the algorithms function correctly and that erroneous outcomes do not harm patients. To this end, AI systems must undergo continuous testing and validation processes should be completed meticulously (Morley et al., 2020).

5.4. Justice

The principle of justice necessitates equitable and fair provision of healthcare services. The high costs of AI systems may render these services inaccessible to certain patient groups. In particular, individuals living in low-income countries or rural areas may lack access to AI-assisted physiotherapy services. Ensuring justice requires making AI technologies more accessible and sustainable (Hagendorff, 2020).

5.5. Transparency and Accountability

The use of AI in healthcare should adhere to the principles of transparency. Healthcare professionals and patients must be informed about how AI systems operate, the datasets on which they are trained, and the types of decisions they can make. Additionally, accountability mechanisms must be established in cases of erroneous decisions made by AI systems. Healthcare professionals should always recognize that AI systems are merely supportive tools and that ultimate responsibility lies with them.

By adhering to these ethical principles, it is possible to ensure safe, fair, and patient-centered use of AI technologies in physiotherapy applications. The ethical use of AI not only safeguards patient rights but also enhances the quality of healthcare services.

6. Opportunities and Ethical Dilemmas of Artificial Intelligence

AI enhances the effectiveness and efficiency of patient care during physiotherapy through various capabilities. AI-based systems have introduced groundbreaking innovations in areas, such as motion analysis, personalized treatment programs, remote patient monitoring, and robotic rehabilitation. However, alongside these opportunities, AI presents several ethical dilemmas.

6.1. Objective and Rapid Assessment

AI-supported systems enable faster and more objective assessments of physiotherapy than manual methods. While this accelerates the patient evaluation process, relying solely on algorithms for decisions can diminish human interaction between the patient and physiotherapist. This mechanization of healthcare services poses an ethical dilemma (Vayena et al., 2018).

6.2. Data Collection and Privacy Risks

AI systems require large amounts of patient data for accurate functioning. Ensuring the security, privacy, and ethical use of such data is critical. In particular, anonymization and secure storage of sensitive health data pose significant ethical and technical challenges (Morley et al., 2020).

6.3. Justice and Access Inequality

Owing to the high costs of AI-supported systems, not all patients can access these services under equal conditions. This poses the risk of technological advancements, further deepening the existing inequalities in healthcare. The accessibility of AI technologies to only economically privileged individuals or institutions undermines the principle of justice in healthcare (Hagendorff, 2020).

6.4. Algorithmic Bias and Responsibility

The reflection of bias in AI training datasets can lead to inaccurate evaluations for certain patient groups. In addition, the question of accountability for errors made by AI systems presents an ethical dilemma.

7. Recommendations for Addressing Ethical Issues

Multidisciplinary and inclusive approaches must be adopted to address the ethical challenges associated with the use of AI in physiotherapy. These recommendations aim to ensure the safe, fair, and ethical use of AI technology.

7.1. Ensuring Data Privacy and Security

Patient data must be anonymized and securely encrypted for storage.

Healthcare professionals and technology developers should avoid sharing patient data without explicit consent.

7.2. Reducing Algorithmic Bias

Training datasets for AI systems should include patients of diverse age, sex, and ethnic groups.

Regular testing and validation of the AI algorithms must be ensured.

7.3. Ensuring Access and Equity

The cost of AI-based physiotherapy services should be reduced to make them accessible in economically disadvantaged regions.

Thus, AI technologies should be integrated into public healthcare systems.

7.4. Establishing Accountability and Transparency Mechanisms

The decision-making processes of AI systems should be transparent.

Healthcare professionals should remain the ultimate responsibility for the use of AI tools.

8. Future Perspectives

The use of AI technologies in physiotherapy is expected to expand to broader application areas in the future. Alongside the opportunities that AI will provide in the coming years, more comprehensive ethical regulations are also required.

8.1. Technological Advancement and Integration

AI-powered robotic rehabilitation devices are expected to become more widespread, enabling high-precision motion analysis.

AI systems that are integrated with wearable technologies and sensors can enhance patient monitoring.

8.2. Human-AI Collaboration

In the future, AI systems will be positioned as tools that support physiotherapists' decision-making processes, rather than replacing them. While AI undertakes repetitive tasks, physiotherapists should maintain their central role in human interactions with patients.

8.3. Development of Ethical Regulations

International ethical guidelines for AI use should be established to facilitate standardization.

Healthcare professionals should be educated on AI systems to promote their correct and safe usage.

8.4. Accessibility and Sustainability

As the costs of AI technologies decrease, access to these services for patients in low-income regions increases. This will enable the delivery of equitable and fair physiotherapy services. Future developments in AI and physiotherapy will bring about significant advancements in patient care when utilized within ethical frameworks. Maximizing the benefits of AI is possible through a conscious commitment to ethical responsibility.

9. Conclusion

The integration of AI technologies into the field of physiotherapy has the potential to drive significant transformations in healthcare services. AI-supported systems improve physiotherapy processes in a wide range of areas, from motion analysis to robotic rehabilitation, remote patient monitoring, and personalized treatment planning. These technologies not only enhance patient outcomes but also support physiotherapists in decision-making and increase clinical effectiveness.

However, the use of AI in physiotherapy presents certain ethical challenges. Issues such as patient privacy, data security, algorithmic bias, the role of human factors, and justice highlight the necessity of employing technology within ethical boundaries. Core ethical principles in healthcare—autonomy, beneficence, non-maleficence, and justice—serve as essential guides for the application of AI systems. Ignoring these principles may jeopardize patient safety and exacerbate inequalities in health care services.

In the future, the widespread adoption of AI technologies in physiotherapy requires multidisciplinary collaboration. Healthcare professionals, technology developers, ethicists, and policymakers must collaborate to develop strategies for the safe and ethical use of AI. At the same time, ensuring that AI-based systems are transparent, accountable, and sustainable should be a key objective in making these technologies accessible to everyone.

In conclusion, the opportunities and ethical challenges arising at the intersection of AI and physiotherapy require careful evaluation and a balanced approach. Utilizing the potential advantages of AI in line with ethical values will contribute to delivering safer, more effective, and patient-centered healthcare services in physiotherapy.

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CHAPTER V

Effects Of Clinical Pilates In Pregnancy

Sena Gizem ARSLAN

INTRODUCTION

Pilates

Pilates training increases the endurance, strength and flexibility of all body muscles, especially the core region, while working all body muscles as a group. This exercise method contributes significantly to dynamic posture control, as well as improving the body's balance mechanism (Şimşek D & Katırcı H, 2011). The purpose of calling Pilates "control science" or "contrololology" is to actively include the mind in the program. Pilates, which provides correct posture and increases physical strength, also requires intense mental effort. For this reason, Pilates is called mind-body training (Byrnes K, Wu PJ & Whillier S, 2018, Rogers, Kate & Ann L. Gibson, 2009).

Joseph Pilates, the founder of Pilates, has developed over 600 different exercises from beginner to advanced level. The main purpose of these exercises is to strengthen the core muscles, known as the powerhouse in the body in Pilates, namely the multifidus, transversus abdominus, pelvic floor and diaphragm muscles, and to increase their stabilization. At the same time, it is aimed to reduce the compression pressure applied to the spine by improving the flexibility of the lumbar region muscles (Curnow, Dorothy & et al, 2009, Kloubec & June A., 2010).

Clinical Pilates

Physiotherapist Craig Phillips, who pioneered the establishment of the Australian Physiotherapy and Pilates Institute (APPI), modified Pilates exercises so that they can be performed in the most appropriate way for the body's biomechanical structure. As a result of these studies, the modified Pilates method, known today as clinical Pilates and applied by physiotherapists, has emerged. APPI provides training to many physiotherapists around the world, so that physiotherapists can create Pilates exercise programs suitable for individuals Hides & Julie A & et al., 2011).

There are 8 basic principles of clinical Pilates. These principles are;

- Concentration,
- Breathing,
- Focusing on the center,
- Control, determination,
- Fluidity and harmonization of movements,
- Isolation
- Routine (Karapinar, C & Acar, M, 2024)

Clinical Pilates is used in a wide variety of areas. Although it is used in healthy individuals, clinical Pilates has positive effects in many cases such as musculoskeletal pain (especially low back pain), rheumatological problems, posture disorders, orthopedic traumas, neurological disorders, cancer, osteoporosis, osteoarthritis, scoliosis and pregnancy Wells, Cherie &et al, 2014, Ünal E & Dizmek P, 2014).

Basic effects of clinical Pilates exercises:

- Static and dynamic balance develops,
- Body awareness increases,
- Core stabilization develops,
- Proper posture is achieved,
- Provides motivation and focus.
- Feel more energetic in daily life (Cruz JC, Liberali R & et al, 2016)

Clinical Pilates in Pregnancy

Clinical Pilates exercises are an ideal exercise type for every individual because they are performed in a controlled and safe manner by expert physiotherapists in the field. Clinical Pilates performed during pregnancy positively affects the health of both the mother and the unborn baby. It is a versatile exercise method that increases the psychological and physical strength of pregnant women, especially from the first trimester to the last trimester, prepares them for birth, strengthens their adaptation to the process and helps them return to their previous physical condition and activity levels in the postpartum period. Studies show that one in three women who give birth experience incontinence problems due to weakened pelvic floor muscles after birth. Clinical Pilates exercises have been proven to be effective in improving pelvic floor dysfunction and are used in the treatment of pelvic floor problems (Karapınar C, 2024, Çakmak H.K., 2021).

As the flexibility of the spine increases, the rib cage also rises and thus the fetus has a wider area. This wider area allows the fetus to develop more comfortably. Since the area for the development of the fetus increases, the stress on the pregnant individual will decrease, and symptoms such as back pain may be seen less. In addition, clinical pilates exercises help prevent possible psychological problems by reducing the anxiety level of pregnant women (Winsor, Mari & Mark Laska, 2001).

Balance ability may decrease during pregnancy. The weight gained by pregnant individuals during this period causes the center of gravity to change. At the same time, hormonal changes play an important role in the decrease in balance. Excessive secretion of the relaxin hormone in pregnant women leads to loosening of the ligaments and therefore deterioration of postural stabilization. Another important hormone affecting balance is estrogen-testosterone. In pregnant women, problems in balance, hand-eye coordination and spatial perception occur due to the low secretion of the testosterone hormone than normal. Since testosterone levels increase with exercise, clinical pilates also increases testosterone levels and improves balance (Mitat KOZ., Mustafa Ş & et al, 2016).

There are three phases in the exercise training program during pregnancy. These are warm-up, main load and cool-down phases, respectively. While preparing this exercise training program, care is taken to evaluate the individual from many aspects and to meet their needs (Karapınar C, 2024).

Examples of exercises that can be given in the warm-up phase of clinical pilates:

- Cleopatra exercise

- Toy soldier exercise

- Chest muscle stretching exercises
- Swinging exercise
- Half squat exercise
- Cat-camel exercise (Karapınar C, 2024)

<u>Examples of exercises that can be given in the main loading phase of clinical pilates:</u>

- Single leg stretching exercise
- Toe-heel exercise
- Pelvic tilt exercise on a pilates ball
- Side kick exercise
- Oyster exercise
- Squat exercise with a pilates ball (Karapınar C, 2024)

<u>Examples of exercises that can be given in the cool-down phase of clinical pilates:</u>

- Mermaid exercise
- Rolling exercise
- Chest muscle stretching exercise
- Trunk rotation exercise
- Iliotibial band stretching exercise (Karapınar C, 2024)

Clinical pilates exercises should not be applied in cases where clinical pilates is contraindicated during pregnancy. These situations are shown in Table 1. In addition, there are problems that should be specifically asked to the pregnant woman before the training program shown in Table 2 is prepared. In line with these problems, the pregnant individual should be directed to a physician.

Table 1. Conditions in which clinical pilates is contraindicated in pregnant women

Membrane ruptures	Uncontrolled type 1 diabetes
Pregnancy with risk of premature birth	Hypertension
Unexplained continuous vaginal bleeding	Intrauterine growth retardation
Cervix insufficiency	Presence of hemodynamic heart disease
Pre-emclampsia	Restrictive lung disease
Serious anemia	Placenta Previa (after 28th week)

(Kartal DY, 2024).

Table 2. Problems to be Questioned in the Current Pregnancy

Significant fatigue	Sudden swelling of ankles, hands and face
Vaginal Bleeding	Persistent headaches
Unexplained fainting	No fetal movement after 6th month
Dizziness	Failure to gain weight after 5th month
Unexplained abdominal pain	Sudden swelling of ankles, hands and face
Serious anemia	Persistent headaches

(Kartal DY, 2024).

CONCLUSION

As a result, clinical pilates performed during pregnancy is beneficial for both mother and It positively affects the health of the baby in the womb. It creates a sense of well-being by increasing body awareness in pregnant women. It increases postural stabilization by affecting the secretion level of hormones that play a role in the body's balance system. In addition, clinical pilates exercises help prevent possible psychological problems by reducing the anxiety level of pregnant women. Studies on clinical pilates in pregnant women should be increased and pregnant women should be made aware of this issue.

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CHAPTER VI

The Importance Of Ergonomıcs And Exercıse In Dentıstry

Sena Gizem ARSLAN[1]

Introduction

When we look at the origin of the word ergonomics, it consists of the meanings of "Ergo" (work) and "nomos" (rule/law). In literature, the word ergonomics means the design of the working and living environment in accordance with human characteristics. In other words, ergonomics is the scientific study of the relationship between humans and the workplace environment (Üçüncü & Acar, 2020). Ergonomics is a way to facilitate work by designing tools, equipment, work areas and tasks and making the job suitable for the employee (Çiçek, H., & Çağdaş, A.,2020).

The aims of ergonomics:

- ❖ Ensuring the health and work safety of the employee,
- ❖ Preventing labor losses,

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- ❖ Reducing fatigue and work stress,
- ❖ Reducing work accidents and occupational risks,
- ❖ Increasing productivity and quality,
- ❖ Making the work area safe, healthy and comfortable. (Taşdemir, Koçak & Akın, 2024)(Gupta, 2011)

Postural disorders in the work environment largely lead to musculoskeletal disorders. The increase in musculoskeletal disorders causes many negativities. employers and employees need to take precautions. These precautions usually include ergonomics training, ergonomically designed equipment and treatment approaches (Duray, & Yağci, 2017).

Dentists and Ergonomics

Dentists are occupational workers at risk due to their localized and narrow work areas, repetitive and strenuous movements, using technical tools that create mechanical stress on the musculoskeletal system and constantly standing in a certain position. (Buzak, Ağuş, & Celep, 2019).

Factors affecting pain related to the musculoskeletal system:

- ❖ Challenging movements during daily living activities
- ❖ Physiological traumas
- ❖ Exercises performed without rest
- ❖ Technical tools used in the work environment
- ❖ Static posture
- ❖ Incorrect working posture
- ❖ Long treatment period
- ❖ Age (Parpucu, Ercan, Başkurt, Başkurt, 2023)

In the literature, it has been reported that 60% of dentists have back pain, 56% have neck pain, 44% have hand-wrist pain, and 37% have shoulder pain (Dinçer, Ersoy & Garipağaoğlu 2020). All these musculoskeletal problems cause the person to have poor sleep quality and increase fatigue. As a result, the quality of life in people decreases significantly (Parpucu, Ercan, Başkurt & Başkurt, 2023)

How Should a Good Physician's Posture Be?

- Work should be done at the closest distance to the patient. Excessive bending and twisting should be avoided while at the patient's bedside
- Feet should always be completely on the floor
- An adjustable dentist's chair should be used
- The dentist's chair and the chair on which the patient lies should be positioned appropriately for each other.
- The patient's mouth should be at the dentist's elbow level
- In order to find the appropriate posture for ergonomics, a fixed posture should be avoided until the physician finds the correct posture around the patient.
- Movements that will tire the hand and wrist should be avoided. In difficult movements, force should be applied from the shoulder and elbow.
- When the patient is in the chair, they should try to work lying down horizontally (Szymańska, 2002).

Magnification Devices

Magnification devices such as microscopes, oral cameras, and dental magnifiers are devices frequently used by dentists. Magnification devices allow the dentist to lean at an angle of less than 25 degrees to the patient while working. They play a protective role in problems that may occur due to head and neck strain. Therefore, the use of these devices is important in terms of ergonomics (Kırzıoğlu & Yetiş, 2013).

Dental Unit

The dental unit is the area where doctors work intensively throughout the day, including patients and equipment. Therefore, there are some points that need to be considered ergonomically. These are;

- It should be able to be adjusted vertically and bent horizontally.
- All hand tools used should be within a 54 cm radius circular area that the assistant can reach.
- The cables connected to the unit should not be tangled and should not touch the ground.

- It should be suitable for repeated use and have a sturdy structure.
- Rotating tools should have a locking system (Finkbeiner, 2010).

Doctor's chair

- Although the patient chair is generally focused on due to the risk of pain in terms of ergonomics, the doctor's chair carries this risk more. Therefore, the features that a doctor's chair should have are as follows:
- It should have five wheels.
- It should have back and arm support.
- Height and inclination should be suitable for the person.
- Armrests and elbow support must be present.
- Height should be adjustable independently of the hands
- Seating surface should be flat instead of inclined.
- In the position of sitting leaning back, there should be a distance of 3 fingers between the back of the doctor's knees and the sitting surface.
- The sitting surface of the chair should be covered with seamless fabric (Tokar, Karacaer & Pehlivan, 2014).

Patient Chair

The patient chair is very important for both the doctor and the patient. The criteria for a patient chair to be ergonomically suitable are as follows:

- It should be sturdy.
- It should have a small headrest that is adjustable.
- It should have a back support that is not thick.
- The doctor should be able to get close enough to the patient and place the knees comfortably.
- In order for the doctor to reach the patient more easily, narrow seats should be chosen from the shoulder sections.
- It should be in a way that allows the patient to lie horizontally and has an adjustable height.
- There should be straight or low arm supports.
- It should be rotatable.
- Its height should be adjustable independently of the hands.

- The length of the chair should be long enough for the doctor to work 12 o'clock depending on the dimensions of the clinic.
- It should be ensured that the head support fully supports the patient's head and that the patient is comfortable.
- During the treatment of pediatric patients, 'Pedodontic chair support' should be used. Thus, by elevating the patient, the doctor's access to the oral cavity can be provided with the correct posture.

Positioning of the Pedal

The pedal should be very close to the doctor's foot while the doctor is working. The angle of the knees in this position should be between 90-100 degrees. At the same time, the foot used for the pedal should be changed 2-3 times a day (Tokar, Karacaer & Pehlivan, 2014).

Selection of Hand Tools

The selection of hand tools plays an important role in being able to work with minimum energy and maintaining the normal posture of the hand and wrist. Things to consider when choosing hand tools are as follows:

- Hand tools with the lowest vibration intensity should be selected
- Cordless, light-free hand tools should be selected
- They should have sufficient working power
- Self-illuminating hand tools should be preferred
- Flexible and at the same time lightweight hoses should be preferred
- Those that can rotate around a shaft or axis should be selected
- Easily activated models should be selected
- They should be easy to maintain
- Patients should be given rest breaks between their treatments
- Frequent short breaks should be given during working hours
- Staying in the same fixed position for a long time should be avoided, the working posture should be changed from one side of the body to the other frequently and one muscle should be rested while the other is working

- ❖ Treatment time should be extended in difficult clinical cases
- ❖ One easy and one difficult clinical case should be worked on. (Kırzıoğlu & Yetiş, 2013)(Gupta S., 2011).

Working Timing

To increase efficiency, patients should be given rest breaks between their treatments. Frequent short breaks should be given during working hours. Staying in the same fixed position for a long time should be avoided, the working posture should be changed from one side of the body to the other frequently and one muscle should be rested while the other is working. In difficult clinical cases, the treatment period should be extended and one easy and one difficult clinical case should be worked on (Gupta S., 2011). Frequent short breaks should be as follows:

- ❖ Stretching exercises should be done (While waiting for the local anesthesia to take effect, while putting on gloves, while mixing the impression material, etc.).
- ❖ In addition to stretching exercises, the forearms should be rested by placing them on the support in the dentist's chair.
- ❖ One should be on the move to prevent long-term static muscle contraction. Working by sitting for a while and standing for a while activates different muscle groups.
- ❖ Frequently changing the foot on which the weight is placed while standing prevents the contraction of a single back muscle group (Tokar, Karacaer & Pehlivan, 2014).

Stretching Exercises

Dentists should do stretching exercises regularly and frequently during the day. With stretching exercises; conditions such as ischemia, muscle imbalance, trigger point, nerve compression, joint hypomobility and disc degeneration are prevented, blood flow to the muscles is increased, synovial fluid production in the joint is increased, trigger point formation is reduced, and continuity of normal joint movement is ensured. (Valachi & Valachi, 2003)(Tokar, Karacaer & Pehlivan, 2014).

Things to consider when doing stretching exercises are as follows:

- The starting point for stretching should be determined
- Deep breath should be taken.
- Wait for two to four breaths in and out in the stretching position.
- Slow exhalation should be done to increase the effectiveness of the stretching exercise.
- Slow return to normal position from the stretching position.
- If there is time for stretching exercises, they should be repeated.
- Stretch to the limit of pain.
- Stretching exercises should be done on both sides (Valachi & Valachi, 2003).

Strengthening Exercises

It is important to do strengthening exercises to reduce the risk of musculoskeletal disorders and to increase the durability of the spine, especially for a healthy posture. Strengthening exercises are effective in preventing the muscles from not being nourished enough and not receiving oxygen. Before applying strengthening exercises, a doctor's check-up should be done. Generally, a pilates ball is sufficient for strengthening the back and waist. Although it varies from person to person, it is appropriate to do aerobic exercises 3-4 times a week for 20 minutes. Body weight also has an important effect on spinal health. Because an extra 5 kilos puts a 50 kilo load on the waist (Tokar, Karacaer & Pehlivan, 2014) (Gupta S.,2011).

Stress Management

Since dentists are at-risk professionals, stress also accompanies this situation. The risk of muscle spasms and pain due to stress is high, especially in the back and waist area. Recommendations given by dentists to reduce stress-related muscle spasms;

- Breathing exercises,
- Progressive relaxation,
- Massage,
- Aerobic exercises,
- Meditation,
- Yoga (Tokar, Karacaer & Pehlivan, 2014).

Result

Dentists face many ergonomic hazards and risks. In order to reduce these hazards, employees should be provided with training on the definition of ergonomics, its importance, ergonomically inappropriate situations and precautions that can be taken. In this way, work stress and injury risk are reduced. It should not be forgotten that ergonomics should be considered together with exercises that can be applied during work hours. These exercise practices should be learned by physiotherapists and spread throughout the day. Ergonomic working conditions, exercise and stress management suggestions play an important role in increasing the quality of life.

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BÖLÜM V

Physical Activity and Exercise in Autism Spectrum Disorder

Sedat YİĞİT[1]

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by deficits in social communication and repetitive behaviors (Fombonne, 2003). Clinical features include difficulties with social interaction, language and speech challenges, and repetitive patterns of interest (American Psychiatric Association, 2013). In addition, research highlights that motor impairments, such as poor motor coordination, deficits in fine and gross motor skills, and repetitive stereotypical movements under stress, are commonly observed in individuals with ASD (Fournier et al., 2010). The prevalence of ASD continues to rise, affecting 1 in 88 children, with boys being five times more likely to be diagnosed than girls

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(Cheldavi et al., 2014). Typically diagnosed in early childhood, ASD interventions focus on early treatment during the preschool years, though no curative method has been found to date (Medavarapu et al., 2019).

Children with ASD tend to have insufficient levels of physical activity and face challenges in the development of balance, postural stability, flexibility, and speed, which often leads to various health conditions, inadequate physical development, and poor physical fitness (Ament et al., 2015; Todd, 2012). Insufficient physical activity and a sedentary lifestyle contribute to conditions such as obesity, cardiovascular disease, insulin resistance syndrome, and others. Children with ASD are at special risk for chronic illnesses, and physical activity can be used as an effective method to manage certain health issues (Bodnar et al., 2020).

Between 79% and 83% of children with ASD experience difficulties in performing age-appropriate motor skills (Green et al., 2009). These motor impairments are often observed during childhood and adolescence (Provost et al., 2007). Sensory processing problems, such as tactile hypersensitivity and other sensory modulation disorders, hinder the ability of individuals with ASD to engage in motor activities necessary for learning appropriate motor skills (Robertson & Baron-Cohen, 2017). Differences in social attention, observational learning, and executive functions can affect how individuals with ASD learn motor skills. Additionally, motor skill problems can limit participation in physical activity, which is essential for health (Srinivasan et al., 2014). The literature indicates that children with ASD may experience improvements in social, behavioral, and cognitive skills through exercise and physical activity (Ruggeri et al., 2020).

An interdisciplinary approach is essential for the effective treatment of children with ASD. This involves integrating educational interventions, psychological and behavioral therapies, occupational therapy, speech therapy and physical therapy (Will et al., 2018). In this chapter, the focus will be on exploring the current physical activity and exercise interventions used to support children with ASD.

Physical Activity and Exercise-Based Interventions

Physical Exercise

Current research highlights the positive impact of exercise interventions on individuals with ASD, suggesting that regular physical activity effectively reduces the social, behavioral, cognitive, and motor impairments commonly associated with the condition (Lang et al., 2010). Additionally, reduced physical activity in individuals with ASD is linked to obesity, and exercise is one of the primary strategies for addressing obesity in children with ASD (Young & Furgai, 2016). A study by Pitetti et al. demonstrated that a nine-month treadmill training program for 45 adolescents with ASD and developmental disabilities resulted in a significant increase in calorie expenditure and a decrease in body mass index (BMI) (Pitetti et al., 2007). Most studies in this area implement exercise training 2-3 times per week, with sessions lasting between 20-60 minutes. Aerobic and resistance training are the predominant exercise modalities. Common aerobic exercises include treadmill running, cycling, and water-based activities, all of which have been shown to improve motor skills and physical fitness, reduce undesirable behaviors, and enhance peer relationships and academic performance in children with ASD (Fragala-Pinkham et al., 2011; Lochbaum & Crews, 2003; Pan, 2011). Furthermore, a three-week aerobic exercise program has been reported to improve both sleep quality and motor skills in children with ASD (Brand et al., 2015).

Aquatic exercises differ from traditional exercises due to the unique properties of water, such as friction and buoyancy which help increase muscle strength and improve balance (Kligyte et al., 2003; Nakazawa et al., 1994). These exercises are particularly beneficial for individuals with ASD, as they enhance postural balance (Ansari et al., 2021). According to Ansari et al., aquatic exercises improve postural control, strengthen muscles, and stimulate the central nervous system, leading to enhanced static and dynamic balance in males with ASD. Additionally, aquatic exercise programs have been shown to reduce maladaptive behaviors in children with ASD (Oriel et al., 2017).

Balance problems in individuals with ASD can stem from various factors, including visual and somatosensory processing deficits, basal ganglia dysfunction, hypotonia and increased BMI (Hariri et al., 2022). Balance training, which targets cerebellar function, motor skills, and muscle strength, has been found to improve postural control in individuals with ASD (Cheldavi et al., 2014). For example, exercises such as standing on one foot (with eyes open or closed, on different surfaces) and using a balance board have been shown to reduce mediolateral and anteroposterior sway (Cheldavi et al., 2014). Similarly, short-term rehabilitation programs have demonstrated improvements in postural control parameters, further enhancing balance in individuals with ASD (Caldani et al., 2020).

The selection of exercises for children with ASD should be tailored to their specific motor and social impairments. For example, children with balance disorders may benefit more from riding a supported stationary bike rather than running. Meanwhile, children facing motor coordination challenges can engage in sports activities designed to enhance upper extremity or full-body coordination. Furthermore, the functional level of the child is crucial in determining the appropriate program type: children with low-functioning ASD may thrive in individual-focused programs, while those with high-functioning ASD might respond better to group-based activities (Srinivasan et al., 2014). This personalized approach ensures that exercise interventions are both effective and engaging for each child.

Video Game-Based Exercise

This exercise approach, which utilizes video games to achieve physical interaction, can be considered a low-cost and safe form of exercise for individuals with ASD, as it tends to be more enjoyable than traditional physical activities, positively influencing exercise adherence (Bossink et al., 2017; Must et al., 2015). These games are seen as an important way to encourage exercise in individuals with various conditions, such as hypertension, Parkinson’s disease, and intellectual disabilities (Lima et al., 2020). With advancements in technology, video game-based exercises are viewed as an effective tool for improving physical fitness, cognitive functions, and repetitive behaviors in children and adolescents with ASD (Anderson-Hanley et al., 2011; Getchell et al., 2012). Research indicates that a 20-minute video game-based exercise training program can lead to improvements in repetitive behaviors and cognitive performance in individuals with ASD (Anderson-Hanley et al., 2011). Additionally, video game-based exercise not only reduces repetitive behaviors but also has positive effects on executive functions (Anderson-Hanley et al., 2011). A study examining the effects of video game-based exercise training on Eurofit fitness tests and BMI in children with ASD found improvements in all tests compared to the control group, except for flexibility (Dickinson & Place, 2014). While video game-based exercises can increase physical activity levels in children with ASD, they should not be seen as a replacement for other forms of exercise and physical activities, such as walking or running.

Hippotherapy

Hippotherapy is increasingly recognized as a therapeutic approach with significant medical benefits (Georgieva & Ivanova, 2020). It can effectively enhance children's psychological, cognitive, behavioral, and communication functions, particularly for those with ASD. Occupational therapists, speech therapists, and physical therapists often incorporate this treatment into their interventions (Petersen, 2010). Recent studies highlight the use of hippotherapy for various conditions, including cerebral palsy (CP), multiple sclerosis (MS) (Muñoz-Lasa et al., 2019), and Parkinson's disease (Goudy et al., 2019). Engagement in hippotherapy and interaction with horses can improve communication skills among children with ASD and their peers while enhancing their physical conditions, such as muscle tone, strength, posture, flexibility, balance, coordination, and overall motor functions. The therapeutic effects are largely attributed to the rhythmic oscillations experienced on the back of a moving horse, which influence circulation in muscles and joints through movements occurring in three orthogonal planes (Goudy et al., 2019). Beyond physical health improvements, hippotherapy has also been shown to enhance emotional and social skills in children with ASD. It promotes increased interest, self-confidence, patience, responsibility, and a sense of independence (Andrejeva et al., 2015; Šapurova et al., 2013).

Dance Therapy

ASD is a condition with an unknown exact cause. It is thought that the primary impairment may lie within the mirror neuron system (Ramachandran & Seckel, 2011). Many cognitive neuroscience experts think that this system regulates the psychological mechanisms involved in the interaction between perception and movement. Mirror neurons may be significant for understanding the movements of others and learning new motor skills through imitation. Problems within this system are thought to underlie cognitive disorders such as autism (Dinstein et al., 2008).

Synchronized repetitive movements can enhance the stimuli in the mirror neuron system (Ramachandran & Seckel, 2011). Petrus et al. emphasize the importance of physiotherapy methods in reducing neuromotor impairments (Petrus et al., 2008). Dance therapy is a therapeutic tool based on the theory that the body and mind are interconnected (Levy, 1988). It facilitates the integration of sensation and perception (Gunning & Holmes, 1973). Additionally, when combined with music, it can facilitate social interaction and communication, affecting many systems that intervene in movement perception and ensuring the harmonious functioning of areas responsible for social-emotional and motor functions (Geretsegger et al., 2012). Physical movements such as dancing have therapeutic properties. They are reported to support mental and physical health, improving self-esteem, quality of life, coping skills, and feelings of joy (Takahashi et al., 2019). Furthermore, some researchers report that participation in dance therapy sessions helps children with ASD expand their imagination and enhance their body image (Koch et al., 2016). Positive changes in body awareness and facial expression that directly affect communication are observed in children with ASD undergoing dance therapy (Llaneza et al., 2010). The literature suggests that dance therapy could be effective and applicable in the treatment of children with ASD, facilitating improvements in body and environmental awareness, psychological well-being, and social skills (Koch et al., 2015).

Sports Activities

For individuals with ASD, sports activities can be used as a tool to enhance socio-communicative skills (Chan et al., 2021; Güeita-Rodríguez et al., 2021). It has been noted that sports activities have a positive effect on reducing motor impairments seen in ASD, improving cognitive functions, and enhancing emotional and behavioral adjustment (Levante et al., 2023). Sports activities help to mitigate issues such as difficulties in communicating with their environment and lack of acceptance by society (Parlak et al., 2021). Therefore, engaging in sports activities is particularly important for individuals with autism.

In educational programs designed for individuals ASD, incorporating sports activities that develop motor skills can enhance both movement and social communication abilities (Parlak et al., 2021). The literature includes numerous studies examining the effectiveness of team sports (such as basketball, soccer, and handball) and individual sports (athletics, swimming, horseback riding, and golf) for individuals with ASD. Among these, swimming and horseback riding are considered the most popular sports in the literature (Levante et al., 2023). A study investigating the effects of a sports training program on the physical fitness, self-care, social, and academic skills of individuals with ASD found that a sports training regimen conducted for 16 weeks, four days a week, for seven hours each day, contributed to the development of self-confidence, improved expressive abilities, enhanced musculoskeletal development, and better self-care and academic skills (İbrahim & Kavas, 2022). Special education and sports support children's social skills, academic abilities, and sensory development. Sports, in particular, promote improvements in visual perception and balance skills, daily living activities, executive functions, routines related to sleep-wake cycles and eating, quality of life, self-care, and communication skills. Additionally, sports activities can be used to reduce aggressive behaviors, hyperactivity, and attention deficits (Downey & Rapport, 2012; Durgut et al., 2020; Levante et al., 2023; Parlak et al., 2021). The duration and frequency of sports training are also important for individuals with ASD to achieve better performance. The studies reviewed indicate that sports training sessions should last between 45 to 90 minutes and occur over a period of 7 to 24 weeks. Furthermore, results from research involving short-term sports activities suggest that even brief interventions can be successful (Levante et al., 2023).

Yoga

Yoga is known to affect various parameters of the autonomic nervous system (such as blood pressure, heart rate and respiratory rate), as well as parameters related to the neuromuscular system (Re et al., 2014; Telles et al., 2014). Therefore, the physiological effects of yoga may be relevant for individuals with ASD, who exhibit atypical sensory processing and autonomic and physiological responses to stimuli that differ from those of neurotypical peers (Gwynette et al., 2015). Dysfunction in the central and peripheral nervous systems of individuals with ASD leads to numerous cognitive skill deficits (Eswari & Bhavanani, 2019). As a mind-body practice, yoga helps regulate the nervous system and can be used as a complementary therapy for children with ASD (Koenig et al., 2012). The literature includes studies demonstrating the positive impact of yoga on the severity of autism. A study conducted by Archoudane et al. indicates that yoga has therapeutic effects on children with ASD and reduces the severity of autism (Archoudane et al., 2021). Another study examining individuals with ASD who practiced yoga therapy for eight weeks reported a significant reduction in autism severity (Sotoodeh et al., 2017).

Individuals with ASD often exhibit motor problems such as imitation difficulties, eye-hand coordination issues, postural control challenges, coordination problems, and walking difficulties. The rhythmic movements of yoga can enhance motor and imitation skills, flexibility, posture, and muscle strength in children with ASD (Archoudane et al., 2019). Archoudane et al. suggest that yoga effectively improves grip strength in children with ASD (Archoudane et al., 2021). Another study indicates that a structured yoga program contributes to the development of motor skills (Shanker & Pradhan, 2022). Recently, yoga and other body-focused mindfulness interventions have been used to manage repetitive, self-harming, or aggressive behaviors in children with ASD (Semple, 2019). A study by Narasingharao et al. found that a structured yoga program significantly reduced problematic behaviors such as aggression and self-harm in children with ASD (Narasingharao et al., 2017). Yoga may also help individuals with ASD modulate known hypo-reactivity and/or hyper-reactivity to environmental stimuli (Rogers & Ozonoff, 2005). Furthermore, it has been reported that yoga improves imitation skills, social-communicative behaviors, and quality of life in children with ASD (Radhakrishna et al., 2010). Based on this information, yoga can be considered a therapeutic tool with numerous beneficial effects in the treatment of ASD.

Conclusion

In ASD, where a multidisciplinary approach is crucial, interventions based on physical activities and exercises – such as exercise, sports activities, hippotherapy, dance, and yoga – can serve as therapeutic methods to improve motor skills, repetitive movements, academic performance, cognitive abilities, and social skills.

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