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NEURO PLAY

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NEURO PLAY

D3.3 Monograph/report

Project summary:

NeuroPlay is an ambitious project aimed at boosting children's neurological development while supporting the cognitive and physical health of grandparents through innovative motor-cognitive training. Recognizing the pivotal role grandparents play in children's lives, the project highlights the potential benefits of intergenerational activities for both age groups.
With a global population of 1.5 billion grandparents, NeuroPlay seeks to create engaging exercises and activities that facilitate meaningful interactions between generations year-round. Drawing on expertise from various fields including kinesiology, neuroscience, physical therapy, sports, IT, and certification, the project aims to develop a cutting-edge program rooted in neuroscience principles, with a focus on intergenerational training using lateral motor transfer methodology.
Utilizing established best practices, NeuroPlay will host workshops to disseminate knowledge and methodology to stakeholders. Additionally, the project will organize two summer and two winter camps, providing immersive opportunities for hands-on learning and collaboration. Complementing these efforts, the development of a dedicated NeuroPlay digital platform will allow real-time tracking of participants' progress and incentivize continued engagement in tailored collaborative activities.
By fostering strong intergenerational connections and promoting healthy aging among grandparents, NeuroPlay aligns with key priorities outlined by Erasmus+. This innovative project aims to lay the groundwork for enhanced neurological development in children, contributing to holistic well-being across generations.

Aim of the Report

The aim of this current report is to provide a comprehensive analysis of the NeuroPlay framework—an Erasmus+ Sport initiative that integrates neuroscience, physical activity, and intergenerational play to promote neuroplasticity and lifelong well-being. Specifically, the report seeks to:

- Elucidate the neuro-cognitive foundations that underpin the project, emphasizing the role of physical activity in enhancing brain adaptability across the lifespan;
- Examine how intergenerational motor-cognitive engagement can simultaneously support the developmental needs of children and the preventive health needs of older adults;
- Present the methodological principles of NeuroPlay, including lateral motor transfer and sensorimotor training, as evidence-based strategies for motor and cognitive skill development;
- Contextualize the program within the national landscapes of Slovenia, Bulgaria, and Austria to assess its adaptability and public health relevance; and
- Formulate actionable guidelines and policy recommendations for implementing intergenerational play as a sustainable model for improving physical, cognitive, and social health across generations.

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NEURO PLAY

Continuous Intergenerational Play for Neuroplasticity: An Analysis of the NeuroPlay Framework and its Application in Motor-Cognitive Development Across the Lifespan

Executive Summary

This report provides a comprehensive analysis of the NeuroPlay project, an innovative Erasmus+ Sport initiative designed to foster well-being across the lifespan through structured intergenerational play. Grounded in the principles of neuroscience, the project leverages the powerful bond between children and their grandparents to create a symbiotic health intervention that addresses critical public health challenges: declining physical activity and rising obesity in children, and the physical, cognitive, and social challenges of an aging population.

The scientific foundation of NeuroPlay rests on the brain's capacity for neuroplasticity—its ability to adapt and reorganize in response to experience. Physical activity, particularly when combined with cognitive challenges, is a potent driver of this process. In children, motor-cognitive training is not a dual task but a unified developmental process, where mastering complex movements directly builds the neural architecture for executive functions crucial for academic and life success. For older adults, these same activities serve as a powerful bulwark against age-related decline, enhancing global cognition, building cognitive reserve, and mitigating physical frailty.

An analysis of the partner countries—Slovenia, Bulgaria, and Austria—reveals starkly different baseline conditions. Slovenia and Austria possess strong existing infrastructures for physical education and high, albeit recently declining, levels of youth physical activity. In these contexts, NeuroPlay serves as an innovative enhancement. In Bulgaria, which faces significant challenges with childhood inactivity and obesity, the project functions as a more foundational intervention, filling a critical gap not addressed by formal sports programs.

This report distills the project's methodology into a set of actionable guidelines for practitioners. Central to the NeuroPlay approach is the principle of *lateral motor transfer*, which focuses on training fundamental movement patterns that can be applied to a wide range of activities, accelerating skill acquisition. This is combined with sensorimotor training techniques that manipulate sensory inputs to

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refine movement control and stimulate neuroplasticity. The framework emphasizes the importance of embedding these exercises within engaging narratives and adapting them for collaborative, intergenerational participation.

The impact of the NeuroPlay model is multifaceted. For children, it enhances neuromotor proficiency, builds social skills like empathy and cooperation, and directly supports emotional regulation through the established link between motor control and executive function. For seniors, it provides a powerful preventive framework against physical decline, cognitive impairment, and social isolation, with the intergenerational bond serving as a unique and potent motivator for long-term adherence.

Ultimately, NeuroPlay presents a highly efficient and scalable public health model. By simultaneously addressing the physical, cognitive, social, and emotional needs of two distinct demographic groups within a single, motivating framework, it offers a compelling blueprint for fostering healthier, more connected communities. This report concludes with recommendations for policymakers and practitioners to integrate these principles into broader health and education strategies.

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1.0 The Neuro-Cognitive Foundations of Lifelong Physical Activity (State-of-the-Art Literature Review)

1.1 Neuroplasticity: The Brain's Capacity for Lifelong Adaptation

The central biological mechanism underpinning the NeuroPlay framework is neuroplasticity, defined as the brain's intrinsic ability to reorganize its structure, function, and connections in response to environmental stimuli, learning, and experience.[1] Physical activity (PA) is recognized as a powerful, non-pharmacological method for enhancing this adaptive capacity.[2] The pathways through which PA facilitates neuroplasticity are multifaceted and include the release of neurotrophic factors like Brain-Derived Neurotrophic Factor (BDNF), the modulation of neuroinflammation, a reduction in oxidative stress, and the enhancement of synaptic connectivity and neurogenesis.[2] While this capacity for change is particularly heightened during childhood, it persists throughout the lifespan, enabling continuous learning, adaptation, and recovery from injury.[1]

The mechanisms of neuroplasticity are not uniform across the lifespan but are instead age-sensitive. The developing brain of a child exhibits rapid, *experience-expectant* plasticity, where common environmental inputs shape foundational neural circuits. In contrast, the aging brain relies more heavily on *experience-dependent* plasticity, which can be specifically targeted and stimulated by novel, complex, and engaging activities.[1] The motor-cognitive interventions proposed by NeuroPlay, which combine physical tasks with cognitive challenges in a rich social setting, are ideally suited to serve both functions. For children, these activities enrich an already plastic environment, strengthening developing neural pathways for motor control and executive function. For older adults, they provide the precise, targeted stimuli necessary to induce experience-dependent plasticity, thereby helping to counteract age-related synaptic decline and build cognitive reserve.

1.2 The Symbiotic Relationship between Motor and Cognitive Development in Childhood

A robust body of scientific evidence demonstrates that movement is integral to learning and cognitive development in children. Motor skills and executive functions (EFs)—core cognitive processes including working memory, inhibitory control, and cognitive flexibility—co-develop and are deeply intertwined.[5] This relationship is rooted in shared neural substrates, with overlapping activation in the prefrontal cortex, cerebellum, and basal ganglia during both motor and cognitive tasks.[5] Research indicates that gross motor

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skills are a significant predictor of total EF in preschool children.[7] Furthermore, structured motor learning interventions have been shown to produce significant improvements in working memory, a key component of academic success.[8]

This evidence reframes the role of physical activity in early education. Motor-cognitive training is not merely a "dual-task" for children, where two separate activities are performed concurrently. Instead, it represents a unified developmental process. The cognitive challenges inherent in mastering complex motor skills—such as planning a sequence of movements, monitoring performance for accuracy, inhibiting impulsive actions, and adapting to changing environmental demands—are the very processes that build and refine executive functions.[7] Therefore, programs like NeuroPlay, which leverage the inherent cognitive load of motor learning, do not take time away from cognitive development; they are a direct and effective means of fostering it, making physical education a critical component of cognitive and academic readiness.

1.3 Motor-Cognitive Interventions as a Bulwark Against Age-Related Decline

For older adults, motor-cognitive interventions have emerged as a highly effective strategy to combat age-related cognitive decline. Meta-analyses have shown that training that combines physical and cognitive tasks is superior to single-modality training (i.e., physical or cognitive training alone) for improving global cognition.[9] Different types of exercise confer specific benefits:

- **Aerobic exercise** can increase the volume of the hippocampus, a brain region critical for memory, and improve executive function scores.[2]
- **Resistance training** has been shown to enhance cognitive control and memory performance.[2]
- **Dual-task training**, the core of the NeuroPlay model, directly improves attention and processing speed, which are often affected by aging.[2]

The primary benefit of motor-cognitive training for seniors may lie in its capacity to improve "global cognition"—the brain's overall efficiency and ability to manage complex information—rather than just isolated cognitive domains. While some studies find significant effects on global cognition, the impact on specific domains like memory or attention can be less consistent, particularly in populations with dementia.[9] This suggests that the act of simultaneously engaging motor and cognitive systems forces the brain to optimize resource allocation, enhance coordination between different neural regions, and operate more efficiently as a whole. This process strengthens the underlying neural networks and connectivity, leading to a more resilient and adaptable cognitive system. Consequently, the dual-task nature of NeuroPlay is not just about exercising the body and brain at the same time, but about training the brain's executive control system to manage the complex, real-world tasks that are fundamental to maintaining independence and quality of life in later years.

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1.4 The Power of Intergenerational Connection

Beyond the neuro-cognitive benefits of the activities themselves, the intergenerational context of the NeuroPlay model acts as a potent catalyst, amplifying the program's overall impact. Research consistently shows that intergenerational programs improve social skills, enhance psychological well-being, and reduce age-related stereotypes for all participants.[12] For children, documented benefits include improved empathy, greater social acceptance, better language skills, and enhanced academic performance.[14] For older adults, these programs are a powerful antidote to the modern epidemic of loneliness, leading to decreased social isolation, improved quality of life, a greater sense of purpose and self-worth, and even direct physical health benefits such as reduced falls and increased strength.[14]

Crucially, the presence of children can significantly increase motivation and adherence to physical activity programs for seniors, a key challenge in public health interventions.[15] The NeuroPlay project proposal correctly identifies that many seniors lose the drive to continue with physical exercise in retirement.[16] By embedding motor-cognitive training within the highly motivating and emotionally rich context of the grandparent-grandchild relationship, NeuroPlay effectively overcomes this primary barrier. The social-emotional gains, such as reduced loneliness for seniors and increased empathy in children, are not merely positive side effects; they are integral to the program's success, creating a virtuous cycle of engagement and mutual benefit that a single-generation program cannot replicate.

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2.0 The NeuroPlay Initiative: A Framework for Intergenerational Well-being

2.1 Project Rationale and Core Philosophy

The NeuroPlay project is a direct and timely response to two converging global trends: the rapid aging of society and a concurrent decline in physical activity among children, which contributes to rising rates of childhood obesity.[16] The project's rationale is built upon a simple yet profound observation: the world is home to an estimated 1.5 billion grandparents, a vast and largely untapped resource for promoting health across generations.[16] The core philosophy of NeuroPlay is that children and seniors benefit from similar types of motor-cognitive activities that stimulate neuroplasticity, and that engaging them in these activities *together* provides powerful mutual benefits and overcomes motivational barriers for both groups.[16]

This approach effectively re-conceptualizes the grandparent-grandchild relationship. It moves beyond the traditional roles of informal care or leisure and transforms the interaction into a structured, symbiotic health intervention. The activities are not arbitrary; they are systematically designed by experts in kinesiology, physiotherapy, and other fields to achieve specific, evidence-based health outcomes: strengthening neurological development and motor proficiency in children, while simultaneously supporting the cognitive and physical health of seniors to ensure a higher quality of aging.[16] This reframes the relationship as a partnership for well-being, where each participant's active engagement directly contributes to the other's health.

2.2 The Methodological Keystone: Lateral Motor Transfer

The central training principle of the NeuroPlay project is *lateral motor transfer*. This phenomenon is defined as the process where the experience gained from practicing one motor skill can be efficiently transferred to the learning of another, similar motor skill.[16] For example, the balance and coordination learned while rollerblading can accelerate the process of learning to ice skate. This transfer occurs because the tasks share common elements—such as movements, muscle activation patterns, and sensory inputs—and because the brain can reuse and adapt the neural pathways established through the initial practice. This process is itself a manifestation of neuroplasticity.[16]

The application of lateral motor transfer allows the NeuroPlay program to be both highly efficient and broadly applicable. Instead of teaching dozens of isolated, sport-specific skills, the methodology focuses

on developing foundational movement patterns—such as balancing, rotating, jumping, and coordinating limbs—that form the building blocks for a wide range of life and sport activities. This approach is particularly valuable in an intergenerational context. Learning a complex sport like skiing can be intimidating, especially for older adults or children who are not athletically confident. The lateral transfer approach deconstructs these complex skills into their fundamental components. By first practicing these components in fun, accessible, non-sport-specific games (e.g., balance games during a summer camp), participants build the underlying neural and motor schemas in a low-pressure environment. This pre-training makes the subsequent acquisition of the target sport (e.g., skiing during a winter camp) faster, more intuitive, and more successful, increasing enjoyment and the likelihood of long-term engagement for both generations.[16]

2.3 Project Structure and Activities

The practical implementation of the NeuroPlay project is organized across three main Work Packages (WPs): WP1 (Management & Coordination), WP2 (Events), and WP3 (Communication & Dissemination).[16] The core programmatic activities are housed within WP2, which follows a structured, multi-stage approach to develop, disseminate, and implement the NeuroPlay methodology.

The project's activity cycle begins with an international "Instruction Workshop" (E2.1), a 3-day event designed to bring together experts from the partner organizations to exchange best practices and codify the battery of NeuroPlay activities.[16] This initial phase ensures a consistent, high-quality, and evidence-based foundation for the program.

Following this, the knowledge is disseminated through a series of national "Exchange Workshops" (E2.2-E2.13). These are 1-day events held in Slovenia and Bulgaria, targeting local stakeholders such as trainers, educators, and sports instructors.[16] This stage represents a "train-the-trainer" model, designed to build local capacity and ensure the project's methods can be scaled and sustained beyond the initial project team.

The direct implementation and proof-of-concept phase occurs during the 3-day summer and winter "NeuroPlay Camps" (E2.14-E2.17), held in both Slovenia and Bulgaria. These camps bring together the end-users—children and their grandparents—to participate in a range of motor-cognitive activities, including kayaking, balance training, AcroYoga, and stand-up paddleboarding.[16] These events serve not only to deliver the intervention but also to generate data, feedback, and promotional materials. The entire project is supported by a digital platform designed to share video content and learning materials, further extending the project's reach.[16] This two-pronged approach of direct implementation combined with a train-the-trainer model aims for both immediate impact on participants and the long-term sustainability of the NeuroPlay framework.

3.0 National Contexts for Physical and Cognitive Development

3.1 Analysis of Physical Activity (PA) Levels in Children (up to 10 years)

The NeuroPlay project operates within diverse national contexts, each presenting unique challenges and opportunities. A comparative analysis of physical activity levels among children in the partner countries reveals these differences starkly.

Slovenia: Historically, Slovenia has demonstrated a strong commitment to youth physical activity, reflected in its 'A-' grade on the 2021 Active Healthy Kids Report Card.[17] This success is supported by robust national systems, most notably SLOfit, a comprehensive fitness surveillance system that has monitored schoolchildren since 1983.[18] Despite this strong foundation, recent data indicate a significant negative impact from COVID-19 pandemic restrictions, which led to a substantial decrease across various physical fitness components. The recovery from this decline has been incomplete, signaling a new challenge for a country with a traditionally active youth population.[19]

Bulgaria: Bulgaria presents a contrasting scenario, earning a 'D+' grade for Overall Physical Activity.[20] Only an estimated 30-35% of Bulgarian children and adolescents meet the World Health Organization's recommendation of 60 minutes of daily moderate-to-vigorous physical activity (MVPA).[20] This low activity level is compounded by high rates of sedentary behavior, with approximately 70% of youth exceeding the recommended two hours of recreational screen time per day.[20] Consequently, Bulgaria has one of the highest rates of childhood obesity in Europe, a trend that is worsening.[22] An interesting paradox exists in that participation in organized sports is relatively high ('C+'), suggesting a significant disconnect between structured, formal sport and overall daily physical activity.[20]

Austria: While a specific letter grade is unavailable, data suggest that a large majority of Austrian children, approximately 80%, do not meet recommended PA levels.[23] Studies have identified urban-rural disparities in fitness, with children in rural areas generally demonstrating better physical performance.[24] Similar to Slovenia, Austria experienced a measurable decline in youth fitness following the COVID-19 pandemic, with decreases in cardiorespiratory endurance, agility, and flexibility among primary school children.[25] One meta-analysis estimated that the pandemic resulted in an average reduction of 17 minutes of daily MVPA for children.[26]

These divergent baselines mean that the NeuroPlay project must adapt its strategy in each country. In Slovenia and Austria, the primary challenge is to reverse a recent, pandemic-induced decline and introduce an innovative model to a culture that is already supportive of physical activity. In Bulgaria, the challenge is more fundamental: to build a culture of regular, playful physical activity where it is largely

absent and to combat deeply entrenched issues of sedentary behavior and obesity. The identified gap in Bulgaria between formal sport participation and low overall activity highlights a critical opportunity for NeuroPlay, whose focus on family-based, intergenerational *play* can fill a niche that competitive sport is not addressing.

3.2 National Educational Programs for Physical and Cognitive Development

The formal educational systems in the partner countries provide the backdrop against which out-of-school programs like NeuroPlay operate.

Slovenia: The Slovenian primary school system mandates a significant amount of physical education (PE), with 105 school hours per year (approximately 3 hours per week) for grades 1-6.[27] This is often supplemented by national initiatives like the "Healthy Lifestyle" program, which provides additional hours of physical activity in participating schools.[28] The curriculum also places a strong emphasis on cognitive development, promoting a "learning to learn" competence and supporting holistic, child-centered pedagogical approaches through programs such as "Step by Step".[29]

Bulgaria: PE is a core subject within Bulgaria's centralized national curriculum.[31] In pre-primary education (for ages 3-7), the curriculum includes three weekly sessions of "Physical Culture" alongside subjects like mathematics and language, aiming to develop both physical and cognitive competencies from an early age.[33] However, research suggests that the compulsory PE classes in primary school (typically 3 per week) are insufficient on their own to develop high levels of physical fitness, necessitating engagement in out-of-class activities.[35]

Austria: A new primary school curriculum, implemented from the 2023/24 school year, mandates 2-3 weekly lessons of "Physical Education and Activity".[36] The in-school curriculum is strongly supported by major national initiatives that bridge the gap between schools and community sports. The "Kinder gesund bewegen 2.0" (Move Children Healthily 2.0) program, for instance, is Austria's largest school sports program, fostering cooperation between sports clubs and primary schools to promote an active lifestyle for children aged 2-10.[37] This is complemented by state-wide fitness testing programs like "wie fit bist du" (how fit are you), which provide valuable data for public health strategies.[38] Cognitive development is often supported through play-based and inquiry-led approaches, including psychomotricity projects that link movement and learning.[40]

While all three countries have structured PE within their school systems, the perceived sufficiency and ecosystem of support vary. NeuroPlay's model, which operates primarily through out-of-school workshops and camps, serves as a vital supplement. In Bulgaria, it directly addresses the identified need for more activity beyond the school curriculum. In Slovenia and Austria, its approach aligns perfectly with existing national strategies that already seek to connect schools with community, family, and club-based activities, positioning NeuroPlay as a model that can be readily integrated into established national health promotion ecosystems.

Table 3.1: Comparative Analysis of Partner Country Contexts for Child Development

Indicator	Slovenia	Bulgaria	Austria	Source(s)
Child PA Grade (AHK)	A-	D+	Not Graded	[17]
% Meeting 60min/day MVPA	High (pre-COVID)	~30-35%	~20%	[17]
Childhood Obesity Trend	Some success reversing trend	Among highest in Europe; rising	Rising post-COVID	[22]
Primary School PE	3 hours/week (105 hours/year)	3 sessions/week	2-3 lessons/week	[27]
Key National PA Initiative	SLOfit, Healthy Lifestyle	Development of Students' Sports	Kinder gesund bewegen 2.0	[18]
Cognitive Dev. Approach	"Learning to learn" competence	Centralized state standards	Holistic, play-based, psychomotricity	[29]

4.0 Guidelines for Effective Motor-Cognitive Skill Acquisition

4.1 A Framework for Designing for Lateral Motor Transfer

To effectively design programs that leverage lateral motor transfer, practitioners can follow a systematic, four-step process. This approach deconstructs complex skills into manageable components, builds foundational abilities through varied practice, and then reintegrates them, accelerating the overall learning process.[16]

1. **Deconstruct the Target Skill:** Begin by identifying the complex, real-world skill to be learned (e.g., skiing, kayaking, or a life skill like navigating a crowded space). Analyze this skill and break it down into its fundamental motor components. For skiing, these components would include dynamic balance, core rotation, independent leg action, and rhythmic weight shifting.
2. **Isolate and Train Core Components:** Design simple, engaging, and often non-sport-specific games that isolate and train each of these core components. For dynamic balance, activities could include one-legged stands, walking on a slackline, or using balance boards. For core rotation, exercises might involve throwing games or twisting movements that mimic the action of turning skis.
3. **Vary the Context:** Apply the "principle of variation" by practicing these core components under a wide range of conditions. This could involve changing the surface (stable vs. unstable), speed (slow vs. fast), sensory inputs (eyes open vs. closed), or equipment used. This varied practice builds a robust and adaptable motor schema in the brain, which is essential for transferring the skill to unpredictable, real-world environments.
4. **Re-integrate and Apply:** After the foundational components have been practiced and strengthened, gradually re-integrate them into the context of the original target skill. This creates a clear bridge from the general motor patterns to the specific application, making the final learning phase more intuitive and efficient.

4.2 Principles of Sensorimotor Training: Manipulating Sensory Inputs

Sensorimotor training is a form of applied neuroplasticity designed to enhance movement control by systematically challenging the brain's sensory processing systems, referred to as analyzers.[16] By disrupting habitual sensory-motor patterns, these exercises force the brain to create new, more efficient neural pathways for controlling movement. The "error" or challenge generated by the sensory disruption

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is the direct stimulus for learning and refinement. The core principle involves either restricting or accentuating specific sensory channels.[16]

- **Sensory Deprivation/Restriction:** This technique involves temporarily switching off or limiting one sensory channel to force the other systems to become more acute and reliable.
  - **Optical Analyzer (Vision):** As vision is often the dominant sense for movement control, restricting it is a powerful training tool. Performing balance tasks with one or both eyes closed forces the participant to rely more heavily on the vestibular system (inner ear balance) and the kinesthetic system (body awareness from muscles and joints).[16]
  - **Acoustic Analyzer (Hearing):** Performing rhythmic movements, such as synchronized steps, while wearing earplugs or earmuffs increases the participant's focus on visual cues from a leader and internal kinesthetic feedback.[16]
- **Sensory Accentuation/Overload:** This technique involves adding a specific sensory stimulus to train the brain to filter relevant information from noise and respond accurately under pressure.
  - **Acoustic:** Using verbal commands to dictate changes in movement, speed, or rhythm (e.g., the "Colour drill" where different colors correspond to different postures) trains auditory processing and reaction time.[16]
  - **Tactile (Touch/Pressure):** This involves directing a participant's attention to specific physical sensations during a movement. For example, focusing on the feeling of pressure shifting on the soles of the feet during a balancing task can refine weight-transfer skills. This technique is often more effective with older participants who have more developed differentiated feedback capabilities.[16]
  - **Vestibular (Balance):** To directly challenge the balance system, movements can be performed while gently shaking or tilting the head. This disrupts the stable reference point provided by the inner ear, forcing the neuromuscular system to make rapid adjustments to maintain stability.[16]

4.3 The Art of Engagement: Storytelling and Intergenerational Adaptation

For motor-cognitive programs to be effective, particularly in an intergenerational setting, technical proficiency must be paired with the art of engagement. The following principles are crucial for creating a motivating, inclusive, and enjoyable experience.

- **Create a Narrative:** Abstract drills can be tedious and demotivating, especially for children. By embedding exercises within a compelling story, practitioners can transform a clinical task into an imaginative adventure. As suggested in the sensorimotor training materials, a balance task becomes "crossing a river on a tree trunk," and a movement with closed eyes becomes "navigating a dark cave with Tarzan".[16] This narrative framing enhances engagement, improves retention, and reduces any anxiety associated with performance.
- **Focus on Collaboration, Not Competition:** The program design should prioritize tasks where the different generations must work together to succeed. The example of "Jane leads the blinded Tarzan" is a perfect illustration, requiring trust, clear communication, and shared responsibility.[16]

This shifts the focus from individual achievement to collective success, fostering positive social bonds. Roles can be reversed, allowing the older adult to provide verbal cues while the child performs a physical task, or vice versa.

- **Adapt for Asymmetrical Abilities:** It is essential to recognize that children and grandparents will have different physical capacities. The goal of the activities should be a shared experience, not identical performance. Tasks must be designed with built-in adaptability. For instance, an obstacle course might require a child to jump over a barrier while a grandparent steps over it; the core motor pattern of lifting the leg and maintaining balance is shared, but the execution is adapted to the individual's ability.
- **Empower the Senior Participant:** Intergenerational programs provide a unique opportunity for older adults to impart wisdom and guide a younger generation.[13] By framing the senior as the "guide," "storyteller," or "expert," the program leverages their life experience, enhancing their sense of purpose, fulfillment, and self-esteem.

Scheme 4.1: The NeuroPlay Activity Design Cycle (NP-ADC)

The following scheme outlines a practical, iterative process for developing original NeuroPlay activities that integrate all core principles.

1. **IDENTIFY CORE SKILL:** Select a foundational motor pattern that is a component of a larger skill (e.g., Dynamic Balance, a component of skiing).
2. **CREATE BASE ACTIVITY:** Design a simple, accessible game that targets this skill (e.g., Walk along a rope laid out on the floor).
3. **INTEGRATE SENSORIMOTOR CHALLENGE:** Add a specific sensory manipulation to increase the difficulty and stimulate neuroplasticity (e.g., Perform the walk while looking up at the ceiling, restricting downward vision and forcing reliance on kinesthetic feedback).
4. **ADD COGNITIVE LOAD:** Introduce a simultaneous cognitive task to create a true motor-cognitive exercise (e.g., Name an animal for each step taken along the rope).
5. **EMBED IN NARRATIVE:** Frame the entire activity within an engaging story (e.g., "You are an astronaut walking on a narrow beam on a space station, and you must name the planets you see out the window").
6. **FACILITATE INTERGENERATIONAL LINK:** Define distinct but collaborative roles for each generation (e.g., The grandparent calls out the name of the next planet, and the grandchild has to remember and say it while taking the next step on the beam).
7. **ADAPT & VARY:** Create clear modifications to adjust the difficulty for different ability levels (e.g., The child can hold the grandparent's hand for support; the task can be done faster or slower; the cognitive task can be made simpler or more complex).

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5.0 Developmental Impact: Fostering Neuromotor, Social, and Emotional Skills

5.1 Enhancing Neuromotor Proficiency

The NeuroPlay program is designed to have a direct and lasting impact on the neuromotor proficiency of children. By employing the lateral transfer approach, the activities focus on developing foundational motor competencies, including locomotor skills (e.g., running, jumping), object control skills (e.g., throwing, catching), and stability skills (e.g., balancing).[5] These competencies are the building blocks of "physical literacy" and form the essential foundation for successful participation in a wide range of sports and physical activities later in life.[39] The exercises, which are designed to improve balance, coordination, agility, and strength, provide children with a broad "movement vocabulary".[35] This is critical, as evidence shows that motor competence and physical fitness do not develop automatically but require structured learning and practice.[39] By building this proficiency in a fun, play-based environment, NeuroPlay makes future physical activity more enjoyable and less intimidating, thereby increasing the likelihood of establishing lifelong habits of active living.

5.2 Building the Social Brain through Play

The intergenerational format of NeuroPlay creates a rich social laboratory for developing crucial social-emotional skills. Research on such programs consistently demonstrates benefits for children, including enhanced abilities for cooperative play, greater empathy, and improved social acceptance of others who are different from them.[14] The activities within the NeuroPlay framework are structured to be inherently social and collaborative rather than competitive. Tasks that require communication, turn-taking, and mutual respect help to break down age-related stereotypes and build positive relationships.[12] For example, an activity where a child verbally guides a grandparent with restricted vision, or vice versa, is not just a physical exercise; it is a practical lesson in trust, clear communication, and perspective-taking.[16] The unique dynamic of the grandparent-grandchild relationship, which typically offers more patience and less peer pressure than interactions with classmates, creates an emotionally safe environment for children to practice and internalize these vital social skills.

5.3 The Motor-Emotion Connection: Regulating the Self through Movement

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A significant but often overlooked impact of motor-cognitive training is its direct effect on a child's capacity for emotional regulation. Scientific research has established a clear mediational pathway: improvements in gross motor skills lead to enhancements in executive function, which in turn lead to better emotional understanding and regulation.[7] Executive functions act as the bridge; stronger inhibitory control helps a child manage impulsive emotional responses, greater cognitive flexibility allows them to understand others' emotional perspectives, and a more robust working memory helps them to integrate emotional cues with situational information to produce an appropriate response.[7]

The NeuroPlay program's impact on a child's emotional skills is therefore not an accidental byproduct but a predictable and direct outcome of its core methodology. The program is explicitly designed to improve complex motor skills and challenge executive functions through its integrated motor-cognitive exercises.[16] By implementing this methodology, NeuroPlay directly stimulates the first two stages of this scientifically established developmental pathway. The resulting improvement in emotional regulation—manifested as better impulse control, greater patience, and increased empathy—is a direct, third-order consequence of the program's design, fundamentally linking physical practice to psychosocial health and well-being.

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6.0 A Preventive Framework for Healthy Aging

6.1 Combating Physical Decline: Sarcopenia, Frailty, and Fall Prevention

The NeuroPlay project is explicitly designed as a preventive framework to improve the physical health of seniors and ensure a higher quality of aging.[16] Regular physical activity is a cornerstone of healthy aging, proven to help prevent the onset of sarcopenia (age-related muscle loss) and osteoporosis.[16] Intergenerational programs, in particular, have been shown to be effective in reducing the risk of falls and frailty while increasing strength and balance in older adults.[14] The NeuroPlay activities, which are designed to be enjoyable and adaptable, place a strong emphasis on balance, coordination, and functional exercises.[16] This focus provides a direct and critical intervention for fall prevention, which is a leading cause of injury, loss of independence, and morbidity in the older population. By embedding essential balance and strength training within a fun, play-based context, the program can significantly improve adherence to these crucial but often monotonous exercises.

6.2 Building Cognitive Reserve through Engaging Activity

Beyond physical benefits, NeuroPlay's methodology serves to build and maintain cognitive reserve in its senior participants. It is well-established that physical activity confers benefits for cognitive functions in older adults, and the project's motor-cognitive activities are specifically designed to provide potent cognitive stimulation.[16] The dual-tasking approach, which requires the brain to manage simultaneous physical and mental challenges, is more cognitively demanding and thus more effective at stimulating neuroplasticity than simple physical exercise alone. This is supported by a large body of evidence showing that combined motor-cognitive training is superior to single-modality training for improving global cognition.[9] By constantly introducing novelty and variation in its activities, NeuroPlay directly targets the brain's executive control networks, strengthening their efficiency and building a reserve of neural resources that can help delay or mitigate the effects of age-related cognitive decline.

6.3 The Psychosocial Shield: Mitigating Isolation and Enhancing Well-being

Perhaps the most powerful preventive aspect of the NeuroPlay framework for seniors is its role as a psychosocial shield against isolation, loneliness, and loss of purpose. A key rationale for the project is to

combat the social isolation that can become prevalent in later life.[16] Intergenerational programs are proven to be highly effective in this regard, leading to decreased feelings of loneliness and depression, and significant improvements in quality of life, sense of purpose, self-worth, and empowerment.[12]

The unique motivational structure of NeuroPlay is central to its preventive power. A primary challenge in all healthy aging initiatives is ensuring long-term adherence, as many older adults lose the intrinsic drive to participate in exercise or social programs.[16] NeuroPlay overcomes this barrier by leveraging the profound and pre-existing emotional bond between grandparents and grandchildren.[16] The desire to connect with, teach, and keep up with a grandchild provides a deep, intrinsic, and emotionally resonant reason to stay active—a motivation far stronger than abstract health warnings or clinical prescriptions. In this way, the intergenerational component is not merely an add-on; it is the engine that drives the intervention's sustainability. It transforms what could be perceived as a "health chore" into a meaningful and joyful family activity, ensuring the physical and cognitive benefits are both achieved and maintained over the long term.

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7.0 Synthesis and Future Directions

7.1 Synthesis of the NeuroPlay Model

The NeuroPlay project represents a sophisticated, multi-layered intervention whose total effect is greater than the sum of its parts. It masterfully weaves together three core components—an intergenerational social context, integrated motor-cognitive tasks, and the pedagogical principle of lateral motor transfer—to create a powerful synergy. The intergenerational framework provides the intrinsic motivation and emotional richness that ensures adherence and fosters psychosocial well-being. The motor-cognitive activities deliver a potent, dual-pronged stimulus for neuroplasticity, simultaneously building executive functions in children and cognitive reserve in seniors. The lateral transfer methodology makes the acquisition of new skills efficient and accessible, promoting a sense of mastery and lifelong physical literacy. By simultaneously and symbiotically addressing the physical, cognitive, social, and emotional domains for two distinct demographic groups, the NeuroPlay model stands as a highly efficient and holistic public health intervention.

7.2 Recommendations for Policy and Practice

Based on the analysis of the NeuroPlay framework and the supporting scientific literature, the following recommendations are proposed:

- **For Policymakers:**
  - Integrate intergenerational physical activity programs into national health and education strategies, such as Austria's "Health Targets" or Slovenia's "Healthy Lifestyle" program, to address public health goals for both youth and seniors.
  - Allocate funding for the development and maintenance of community spaces, parks, and facilities that are explicitly designed to be "intergenerationally friendly" and facilitate such interactions.
  - Support the inclusion of intergenerational programming in teacher and coach training curricula to build capacity for delivering these models at the local level.
- **For Educators and Practitioners:**
  - Adopt principles from the NeuroPlay Activity Design Cycle (NP-ADC) as a practical tool for creating engaging and effective motor-cognitive lessons in schools, clubs, and community centers.
  - Integrate sensorimotor training principles into standard Physical Education curricula and therapeutic settings to enhance motor control and stimulate cognitive development.

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- Actively promote collaborative, non-competitive forms of play that involve family members of different generations to supplement formal sports programs and foster a broader culture of physical activity.

7.3 Avenues for Future Research

The NeuroPlay project opens several important avenues for future research to further validate and refine the model:

- **Longitudinal Studies:** Conduct longitudinal research to track the long-term cognitive, physical, and psychosocial health outcomes of children and older adults who participate in NeuroPlay programs, comparing them to control groups.
- **Dosage and Efficacy:** Investigate the optimal "dosage" (frequency, intensity, duration) of intergenerational motor-cognitive activity required to achieve specific, measurable benefits in different age groups and populations (e.g., healthy older adults vs. those with mild cognitive impairment).
- **Comparative Effectiveness:** Design randomized controlled trials to directly compare the effectiveness of the intergenerational NeuroPlay model against traditional, single-generation physical activity programs on measures of adherence, skill acquisition, and psychosocial well-being.
- **Mechanism Exploration:** Utilize neuroimaging techniques (e.g., fMRI, EEG) to further explore the neural mechanisms underlying the benefits of intergenerational motor-cognitive training, examining changes in brain connectivity, structure, and function in both children and older adults.

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9.1 Slovenian version (summary):

Povzetek dokumenta »Continuous Intergenerational Play for Neuroplasticity (NeuroPlay)«

Projekt NeuroPlay je evropska Erasmus+ pobuda, namenjena spodbujanju nevroplastičnosti in dobrega počutja skozi medgeneracijsko igro, ki povezuje otroke in njihove stare starše. Cilj je hkrati krepiti nevrološki razvoj otrok ter fizično, kognitivno in socialno zdravje starejših. Projekt temelji na znanstvenih spoznanjih o vlogi telesne aktivnosti pri prilagodljivosti možganov in poudarja pomen gibalno-kognitivnih dejavnosti za celostno zdravje.

Jedro projekta je načelo lateralnega motoričnega prenosa, po katerem vadba ene gibalne spretnosti olajša učenje druge, sorodne spretnosti (npr., ravnotežje in koordinacija, pridobljena med rolanjem, lahko pospešita proces učenja drsanja na ledu). S tem se razvijajo osnovni gibalni vzorci, ki pospešijo učenje in povečajo samozavest udeležencev. Program vključuje senzomotorični trening, pri katerem se z nadzorovanimi senzoričnimi spremembami (npr. vaja z zaprtimi očmi, naloge na nestabilnih površinah) spodbuja natančnejše zaznavanje in uravnavanje gibanja – s tem pa tudi delovanje centralnega živčevja.

Projekt vključuje tri partnerske države – Slovenijo, Bolgarijo in Avstrijo – ter organizacije s področij kineziologije, športne vzgoje, nevroznanosti in terapije. V vsaki državi se dejavnosti prilagajajo nacionalnim posebnostim:

- V Sloveniji in Avstriji projekt nadgrajuje že dobro vzpostavljene sisteme gibalne/športne aktivnosti in spodbuja inovativne oblike gibalnega učenja po pandemiji COVID-19.
- V Bolgariji pa zapolnjuje vrzel nizke telesne aktivnosti otrok in visokih stopenj debelosti ter vzpostavlja kulturo družinskega gibanja zunaj formalnih športnih okvirjev.

Osrednje aktivnosti vključujejo mednarodne izobraževalne delavnice, nacionalne izmenjave znanj in poletne ter zimske tabore, kjer otroci in stari starši skupaj izvajajo gibalno-kognitivne igre, kot so hoja po vrvi, vaje ravnotežja, acroyoga, veslanje in supanje ipd.

Na znanstveni ravni poročilo pojasnjuje, da je telesna dejavnost ključni spodbujevalec nevroplastičnosti skozi vse življenje. Pri otrocih izboljšuje izvršilne funkcije (spomin, samokontrolo, prilagodljivost), pri starejših pa krepi kognitivno rezervo in preprečuje upad kognitivno-gibalnih funkcij. Kombinacija gibalnih in kognitivnih izzivov dokazano izboljšuje globalno kognicijo, ravnotežje in gibalno učinkovitost.

Projekt ima tudi izrazit socialno-emocionalni učinek. Otroci skozi sodelovanje razvijajo empatijo, sodelovanje in zaupanje, starejši pa občutek pripadnosti, namena in zmanjšano osamljenost. Medgeneracijska povezanost deluje kot močan motivacijski dejavnik za dolgotrajno aktivnost, kar pogosto manjka pri enogeneracijskih programih.

Vplivi projekta so večplastni:

- Za otroke: boljša gibalna pismenost, izvršilne funkcije in čustveno regulacijo.
- Za starejše: večja telesna moč, ravnotežje, kognitivno vitalnost in socialno vključenost.
- Za skupnost: trajnostni model zdravega staranja in povezanosti generacij.

Poročilo zaključuje s priporočili za politike in praktike – vključitev medgeneracijskih programov v nacionalne strategije zdravja in izobraževanja, oblikovanje intergeneracijskih prostorov ter usposabljanje učiteljev in trenerjev za uporabo metodologije NeuroPlay. Projekt tako predstavlja holistično, znanstveno utemeljeno in razširljivo javnozdravstveno orodje, ki povezuje telesno, kognitivno in socialno dimenzijo človekovega razvoja skozi igro. Zaključke projekta je potrebno še dodatno znanstveno oceniti ter nadgraditi z izvedbo morebitnega novega (obširnejšega) projekta med obstoječimi partnerskimi inštitucijami ter širše.

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9.2 German version (summary):

Zusammenfassung des Projektes: Continuous Intergenerational Play for Neuroplasticity (NeuroPlay)«

Das Projekt NeuroPlay ist eine europäische Erasmus+-Initiative zur Förderung der Neuroplastizität und des Wohlbefindens durch generationsübergreifendes Spielen, das Kinder und ihre Großeltern zusammenbringt. Ziel ist es, gleichzeitig die neurologische Entwicklung von Kindern und die körperliche, kognitive und soziale Gesundheit älterer Menschen zu stärken. Das Projekt basiert auf wissenschaftlichen Erkenntnissen über die Rolle körperlicher Aktivität für die Anpassungsfähigkeit des Gehirns und betont die Bedeutung motorisch-kognitiver Aktivitäten für die ganzheitliche Gesundheit.

Im Mittelpunkt des Projekts steht das Prinzip des lateralen motorischen Transfers, wonach das Training einer motorischen Fertigkeit das Erlernen einer anderen, verwandten Fertigkeit erleichtert (z. B. können das Gleichgewicht und die Koordination, die beim Inlineskaten erworben werden, den Prozess des Erlernens des Eislaufens beschleunigen). Dadurch werden grundlegende Bewegungsmuster entwickelt, die das Lernen beschleunigen und das Selbstvertrauen der Teilnehmer stärken. Das Programm umfasst sensomotorisches Training, bei dem durch kontrollierte sensorische Veränderungen (z. B. Übungen mit geschlossenen Augen, Aufgaben auf instabilen Oberflächen) eine genauere Wahrnehmung und Steuerung der Bewegung gefördert wird – und damit auch die Funktion des zentralen Nervensystems.

Das Projekt umfasst drei Partnerländer – Slowenien, Bulgarien und Österreich – sowie Organisationen aus den Bereichen Kinesiologie, Sportpädagogik, Neurowissenschaften und Therapie. In jedem Land werden die Aktivitäten an die nationalen Besonderheiten angepasst:

• In Slowenien und Österreich baut das Projekt auf bereits gut etablierten Systemen für Bewegungs-/Sportaktivitäten auf und fördert innovative Formen des Bewegungslernens nach der COVID-19-Pandemie.

• In Bulgarien schließt es die Lücke zwischen geringer körperlicher Aktivität von Kindern und hohen Adipositasraten und schafft eine Kultur der Familienbewegung außerhalb formaler Sportkontexte.

Zu den zentralen Aktivitäten gehören internationale Bildungsworkshops, nationale Wissensaustausche sowie Sommer- und Wintercamps, in denen Kinder und Großeltern gemeinsam motorisch-kognitive Spiele wie Seiltanzen, Gleichgewichtsübungen, AcroYoga, Rudern und Stand-up-Paddling usw. durchführen.

Aus der wissenschaftlichen Betrachtungsebene stellt der Bericht dar, dass körperliche Aktivität ein wichtiger Förderer der Neuroplastizität während des gesamten Lebens ist. Bei Kindern verbessert sie die exekutiven Funktionen (Gedächtnis, Selbstkontrolle, Anpassungsfähigkeit), bei älteren Menschen stärkt sie die kognitiven Reserven und verhindert den Rückgang der kognitiven und motorischen Funktionen. Die Kombination aus motorischen und kognitiven

Herausforderungen verbessert nachweislich die globale Kognition, das Gleichgewicht und die motorische Leistungsfähigkeit.

Das Projekt hat auch eine ausgeprägte sozial-emotionale Wirkung. Durch die Zusammenarbeit entwickeln Kinder Empathie, Zusammenarbeit und Vertrauen, während ältere Menschen ein Gefühl der Zugehörigkeit und Sinnhaftigkeit entwickeln und weniger unter Einsamkeit leiden. Die generationsübergreifende Verbundenheit wirkt als starker Motivationsfaktor für langfristige Aktivitäten, was bei generationenübergreifenden Programmen oft fehlt.

Die Auswirkungen des Projekts sind vielfältig:

• Für Kinder: verbesserte motorische Fähigkeiten, exekutive Funktionen und emotionale Regulation.

• Für ältere Menschen: mehr körperliche Kraft, Gleichgewicht, kognitive Vitalität und soziale Integration.

• Für die Gemeinschaft: ein nachhaltiges Modell für gesundes Altern und generationsübergreifende Verbundenheit.

Der Bericht schließt mit Empfehlungen für Politik und Praxis – Einbeziehung generationsübergreifender Programme in nationale Gesundheits- und Bildungsstrategien, Schaffung generationsübergreifender Räume und Schulung von Lehrern und Trainern in der Anwendung der NeuroPlay-Methodik. Das Projekt stellt somit ein ganzheitliches, wissenschaftlich fundiertes und erweiterbares Instrument für die öffentliche Gesundheit dar, das die körperliche, kognitive und soziale Dimension der menschlichen Entwicklung durch Spiel miteinander verbindet. Die Ergebnisse des Projekts müssen noch zusätzlich wissenschaftlich bewertet und durch die Durchführung eines möglichen neuen (umfangreicheren) Projekts zwischen den bestehenden Partnerinstitutionen und darüber hinaus weiterentwickelt werden

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9.3 Bulgarian version (summary):

Bulgarian version (summary):

„Непрекъсната междупоколенческа игра за невропластичност (NeuroPlay)“
Проектът **NeuroPlay** е европейска инициатива по програма Erasmus+, насочена към насърчаване на **невропластичността** и **благополучието** чрез **междупоколенческа игра**, която свързва **деца и техните баби и дядовци**.
Целта е едновременно да се укрепи **неврологичното развитие на децата** и да се подобри **физическото, когнитивното и социалното здраве на възрастните хора**. Проектът се основава на научни доказателства за ролята на физическата активност в адаптивността на мозъка и подчертава значението на **двигателно-когнитивните дейности** за цялостното здраве.
В основата на проекта стои **принципът на латералния моторен трансфер**, според който упражняването на едно двигателно умение улеснява усвояването на друго, сродно умение (например балансът и координацията, придобити при каране на ролери, могат да ускорят процеса на учене при пързаляне с кънки на лед).
По този начин се развиват основни двигателни модели, които ускоряват ученето и повишават самоувереността на участниците. Програмата включва **сензомоторни тренировки**, при които чрез контролирани сензорни промени (напр. упражнения със затворени очи, задачи върху нестабилни повърхности) се стимулира по-прецизното възприемане и регулиране на движенията – а оттам и функционирането на централната нервна система.
Проектът включва **три партньорски държави – Словения, България и Австрия**, както и организации в областите на **кинезиологията, физическото възпитание, невронауката и терапията**.
Във всяка страна дейностите се адаптират към националните особености:

- **В Словения и Австрия** проектът надгражда вече добре установени системи за двигателна/спортна активност и насърчава иновативни форми на двигателно обучение след пандемията от COVID-19.
- **В България** пък запълва пропастта, свързана с ниската физическа активност при децата и високите нива на затлъстяване, като създава култура на **семейно движение извън формалните спортни рамки**.

Основните дейности включват **международни обучителни работилници**, **национални обменни програми за знания**, както и **летни и зимни лагери**, където деца и баби/дядовци заедно изпълняват двигателно-когнитивни игри като **ходене по въже, упражнения за баланс, акройога, гребане и SUP** и др.
На научно ниво докладът подчертава, че **физическата активност е ключов стимулатор на невропластичността през целия живот**. При децата тя подобрява **изпълнителните функции** (памет, самоконтрол, адаптивност), а при възрастните – **укрепва когнитивния резерв** и **предпазва от упадък на когнитивно-двигателните функции**.
Комбинацията от двигателни и когнитивни предизвикателства доказано подобрява **общите познавателни способности, баланса и двигателната ефективност**.
Проектът има и изразен **социално-емоционален ефект**. Децата чрез участието си развиват **емпатия, сътрудничество и доверие**, а възрастните – **усещане за принадлежност, цел и намалена самота**. Междупоколенческата връзка действа като **силен мотивационен фактор** за дългосрочна активност – нещо, което често липсва в еднопоколенческите програми.
Ефектите на проекта са **многостепенни**:

- **За децата:** по-добра двигателна грамотност, изпълнителни функции и емоционална регулация.

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- **За възрастните:** по-голяма физическа сила, баланс, когнитивна жизненост и социална ангажираност.
- **За общността:** устойчив модел на здравословно стареене и свързаност между поколенията.

Докладът завършва с **препоръки към политици и практици** – да се интегрират междупоколенчески програми в националните стратегии за здраве и образование, да се създават междупоколенчески пространства и да се обучават учители и треньори за прилагане на методологията NeuroPlay.

Проектът представлява **холистичен, научно обоснован и мащабен инструмент за обществено здраве**, който свързва физическото, когнитивното и социалното измерение на човешкото развитие чрез игра.

Заключенията на проекта следва да бъдат **допълнително научно оценени** и надградени чрез евентуално нов (по-обширен) проект между съществуващите партньорски институции и извън тях.

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