

Emilia Mikołajewska<sup>1,2</sup>, Beata Augustyńska<sup>3</sup>, Dariusz Mikołajewski<sup>4,2</sup>

## **ROLE OF MOBILITY IN COGNITIVE DEVELOPMENT OF CHILDREN WITH MOTOR DEFICIT – OWN OBSERVATIONS OF WHEELCHAIRS USERS**

### **ROLA MOBILNOŚCI W ROZWOJU POZNAWCZYM DZIECI Z DEFICYTEM MOTORYCZNYM – OBSERWACJE WŁASNE UŻYTKOWNIKÓW WÓZKÓW DLA DZIECI NIEPEŁNOSPRAWNYCH**

<sup>1</sup>Department of Physiotherapy, Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń, Poland

<sup>2</sup>Neurocognitive Laboratory, Centre for Modern Interdisciplinary Technologies, Nicolaus Copernicus University in Toruń, Poland

<sup>3</sup>Department of Biochemistry, Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń, Poland

<sup>4</sup>Institute of Mechanics and Applied Computer Science, Kazimierz Wielki University in Bydgoszcz, Poland

#### **S u m m a r y**

Wheelchair plays two important roles from the physical point of view: increased mobility and body support. Two main areas of children's development: motor and cognitive are interrelated. Thus, wheelchair supported mobility in children may also prevent many severe problems in the area of social and cognitive development.

This paper aims at presentation of current state of the art and own concept concerning the role of the wheelchair-based mobility in cognitive development of children with motor deficit.

#### **S t r e s z c z e n i e**

Z fizycznego punktu widzenia wózek dla osób niepełnosprawnych odgrywa ważną rolę w zwiększeniu mobilności oraz podparciu ciała. Dwa obszary rozwoju dziecka są powiązane: rozwój motoryczny i rozwój poznawczy. Stąd mobilność dziecka wspomagana za pomocą

wózka może również zapobiec wielu różnym problemom w obszarze rozwoju społecznego i poznawczego.

Artykuł ma na celu prezentację stanu obecnego oraz własnych koncepcji w obszarze roli mobilności dziecka wspomagane wózkiem w rozwoju poznawczym dzieci z deficytem motorycznym.

**Key words:** physical activity, recreation, play, cognitive development, quality of life, disabled children

**Słowa kluczowe:** aktywność fizyczna, rekreacja, zabawa, rozwój poznawczy, jakość życia, dzieci niepełnosprawne

#### **INTRODUCTION**

Cognitive development of children is influenced by many factors, including their age, activities of their parents, caregivers and peers, stimuli from environment and ability to move toward the stimulus

and response to it. Self-generated mobility is necessary for proper development of children in all areas: physical, emotional, cognitive, and social; thus, self-locomotion deficits may increase the risk of developmental delays. According to the systematic review by Bray et al., wheelchairs dedicated for

disabled children may provide health, developmental and social benefits. It seems children can learn (to some degree) of powered wheelchair driving competence from 14 months of age. Such approach offers not only improved mobility and independence (independent movement), but also reduced need for caregiver assistance as far as improved personal, social and cognitive development is concerned [1].

Current evidence in the area of role of mobility in cognitive development of children with motor deficit is limited and of low quality. Both powered and self-propelled wheelchairs may be very useful, but their influence on the way and pace of cognitive development is barely known. Improvement of social skills and child's independence is the primary benefit described by parents, caregivers, and medical staff.

This paper aims at presentation of current state of the art and own concept concerning role of the wheelchair-based mobility in cognitive development of children with motor deficit.

#### WHEELCHAIR SUPPORTED MOBILITY IN CHILDREN

Wheelchair plays two important roles from the physical point of view: increased mobility and body support. Wheelchair supported mobility in children may also prevent many severe problems in the area of social and cognitive development. Study by Travlos et al. showed that despite relatively low physical quality of life (QoL) in wheelchair users - children with neuromuscular disorders, their psychosocial QoL was similar to that reported in the same age peers [2]. Early and timely part-time powered wheelchair introduction in children with Duchenne muscular dystrophy motivates their activity, promotes their maximal participation and further psychosocial development [3]. Systematic review by Livingstone and Field showed low number of relevant studies in the aforementioned area: from 259 papers only 28 (10.81%) described primary research studies; thus, current state-of-the-art may be regarded as rather descriptive than experimental. Despite aforementioned weakness at least several studies tried to explain the current situation within wheelchairs for children based on International Classification of Functioning, Disability and Health (ICF) components: body structure and function, activity and participation [4]. It may be an important step toward standardized protocol of

randomized controlled trials in the aforementioned area.

No doubt externally supported mobility may prevent cognitive delay broadening possibilities of environment exploration, communication, and social participation. From the other hand, wheelchair-dependent movement in children may be limited and delay development of the other skills (gross motor skills, movement planning, distance assessment, etc.). We should take into consideration even alternative future solutions such as exoskeletons may show adverse effects due to e.g. lack of free movement within the environment.

There is a need to monitor and quantify physical behavior in wheelchair-dependent children due to possible development of unfavorable physical behavior [5]. Thus, "keep fit" interventions [6, 7] and proper adaptation of the popular activities to requirements of the wheelchair-dependent children (fig. 1, fig. 2) and their evaluation are needed. This waysupporting of the natural and motivating learning through play may be optimized.

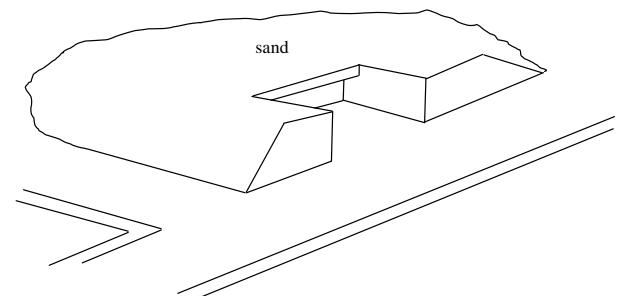


Fig. 1. *Sandbox for child on wheelchair* [8]

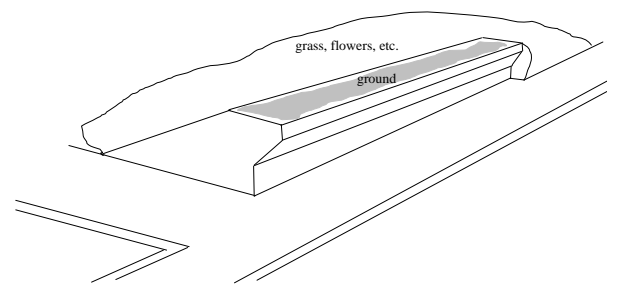


Fig. 2. *Raised garden for children on wheelchairs* [8]

We should be aware that concepts, designs and technologies in the area of wheelchairs for children develop significantly; thus, some older studies may be non-significant. There is a need for deeper critical analysis of studies before we include them into review.

## OWN CONCEPTS AND RESEARCH

Results of own observation of children developing on wheelchairs showed that every limitation of children's motor activity may negatively influence their cognitive development and of course motor development. Potential causes of the motor activity limitation in children include e.g. paresis/plegia, amputation or developmental abnormalities in the area of lower limbs. Such problems may limit children's experience of the surrounding world in lying and sitting positions. Active exploration is more valuable than passive motion or lack of motion. Some of the aforementioned limitations may be overcompensated thanks to hard work of parents, caregivers, teachers, physical therapists, etc., but it may be time-consuming, exhaustive and, in some cases, beyond the reach. Aforementioned situation imposes also use of assistive technology – the most frequent solution is wheelchair for children. Use of wheelchair limits motor abilities of a child due to limited area of the voluntary movements and lack of possibility of unrestricted movements in surrounding space. Such situation decreases number of the sensory stimuli, ability to feel changes of the position in the space, etc., what negatively influences the development of balance sense. Aforementioned restriction makes it difficult to actually get any kind of picture on the world child lives in. Number of observed objects decreases, all of them are observed from the same position on wheelchair (thus, influences child's imagined perspective). We should be aware that observing activities of other children/people constitutes a common way to pick up a new movements and acquiring new skills in children. Limited number of movement patterns observed and restricted ability to imitate them may influence e.g. pace of the development and variety of movements. Moreover, visual and acoustic action-related inputs and cues may help children be aware of the stimulus, its meaning, and required response. Despite normally developing central nervous system and hand function (touch, gestures, feelings expression) and achievement of the cognitive skills regarded as the most advanced (e.g. creative writing/painting, playing of musical instruments), advancement of some skills may develop to slow (it may be compared to e.g. lack of clear vision influencing fulfilling of some tasks). Fewer objects are within the reach of the hands; thus, fewer objects are touched (this may influence child's imagination and assessment of size, texture, density, weight, and shape

of objects at different distances). Action-selection may be significantly disturbed by the imagined or real limitations, e.g. distance to the reached object. Relationships to peers may be significantly influenced in children on wheelchair: toys are still useful therapeutic tools, but they may play limited role as mediators of movement patterns within group activities and social behaviors. Participation in some games requiring floor activities or climbing are beyond the reach. Moreover, some activities concerning object sharing, transfer, hiding, etc. are severely limited.

The problem described may be deeper in the case of coupled disorder of the upper limbs, what makes self-propeller movement difficult or even impossible and limits independence of the child. Multisensory disorder or intellectual disorder may cause difficult to spell out clearly ask for change position/place of the wheelchair. Additionally, integration of information gathered from various senses, their selection (some of them may be disturbed or incomplete), context-aware analysis, and decision-making process may need more effort and time. Even more challenging may be understanding of the spatial and temporal succession of changes. This issues may be reflected in planning of the motor strategies by children on wheelchairs, incorporating odd previous experiences compared with e.g. running children.

Aforementioned situation requires:

- translation of medical and non-medical recommendations into everyday practice,
- extended awareness form parents, caregivers, and medical staff,
- early diagnosis,
- sensitivity to changes, in both physical and cognitive areas,
- integrative, patient-oriented therapeutic approach (see e.g. various possible interventions concerning improper velocity or quality of movement, since quick movement not always has a proper trajectory, etc.),
- effort and time need for explanation, demonstration, and repetitive tasks imitating attractive play concerning acquiring new movements, experiences, skills – therapeutic toys or robots-companions may be very useful to promote required healthy activities in children,
- flexible plan of the therapeutic intervention, engaging parents and caregivers, almost 24/7, during activities of daily living,

- maintaining of the physical activity of the child allowing for normal independent functioning (wheelchair is usually self-propelled).

We should put particular attention to acquiring ADL skills despite decreased mobility. Such abilities, even impaired or supported by assistive technology are very precious because of the independence of child. They are equivalent of the traditional behavior and increase self-esteem of the child.

## CHALLENGES AND LIMITATIONS

Two main areas of children' development: motor and cognitive are interrelated. It seems that people who learned to walk earlier preserved better cognitive performance in early old age [9]. Thus, development and maintaining of the motor skills seem be critical for proper development of cognitive skills. Additionally, development of language and cognitive skills needs to take into consideration results of the surrounding world exploration: changing experience and competence, as far as current context. Thus, proper motor development is important for both cognitively developing children, and children with cognitive problems. Full understanding of this "hidden" relationship may influence everyday clinical practice, e.g. may improve social development in children with Autism Spectrum Disorders (ASD) [10]. Moreover, better locomotion may improve cognitive development in children with meningomyelocele (MMC) and hydrocephalus [11]. Despite efforts of parents and medical staff perception of the external world in children and associated formation of the cognitive structures (representation of self and surrounding objects) may be disturbed [12], thus careful observation, early diagnosis and intervention are needed. We should better understand and influence way children gather information concerning the environment, and build and utilize their knowledge and experience (e.g. distinguishing of acquiring sensations, perceptiveness and attention). Aforementioned process may be individual. Thus, not every change constitutes a symptom enabling to differentiate or diagnose child with a disorder [13].

There is a need for pre-programmed models of intervention and support, avoiding generation of pathological changes, used as learning proposals and easy to modify. Main limitations of the aforementioned concept are:

- few studies and publications, especially fulfilling requirements of the evidence-based medicine (EBM) paradigm,
- incomplete understanding of related mechanisms,
- unification and standardization of assessment and diagnosis,
- lack of precise indications, contraindications, and secondary changes,
- social awareness among medical staff and patients.

Aforementioned limitations can be overcome by common cooperation of scientists and clinicians.

## DIRECTIONS FOR FURTHER RESEARCH

Future research should focus on outcome measures/tools development and incorporating them into:

- high quality studies to address research gaps,
- everyday clinical practice,
- home care, including long-term use of wheelchairs.

Moreover, further studies should describe intervention strategies used to enhance cognitive functioning. Particular attention should be paid to acquiring and maintaining skills such as joint attention, imitation, memory, creative problem solving, and knowledge/experience-based decision making [14].

Novel technologies may significantly change current situation. The further development of the wheelchairs accompanied by therapeutic application of toys, games, and cognitive robots may open new directions toward activity monitoring, activity eliciting and learning (e.g. repetitive tasks versus single toy-associated meaningful task), social interaction, and even group behavior [15-19].

Further research in the area of wheelchairs aims at introduction of novel families of wheelchairs for children, significantly increasing their independence and safety. Associated attractive form may increase acceptance rate in children. Aforementioned situation may shape better social awareness of the disabled people, and well-designed assistive device may become object of focus of the peers not as, but rather as up-to-date stylish accessory (take into consideration example of an exoskeleton as Iron Man gadget).

Increasing prevalence of use of smartphones and tablet computers within various social activities decreases role of physical activity in the shaping relationships with peers. Physical activity in children

on wheelchairs remains an important element of the general condition, sport and leisure activities. Despite mobility limitations most of the occupations of tourism and recreation are still available.

Artificial environments (virtual reality, augmented reality) are regarded as more advanced alternatives for current traditional human-computer interface. Children with motor disorders may modify their activity according to the demands of the proposed therapeutic scenario (e.g. VR-based), taking into consideration level and severity of their cognitive and motor disorders.

## CONCLUSIONS

The influence of motor skills to the way and pace of cognitive development may be so great that may cause life-long changes concerning further functional and cognitive abilities. Mobility needs and abilities of disabled children may be equally important as health care services, environment experiencing, social participation and development of meaningful relationships. Thus, wheelchair-related interventions are of high priority not only due to related independence, but also psychosocial outcomes and cognitive development.

## ACKNOWLEDGEMENTS

This work was conducted as a part of work within a project "NeuroPerCog: development of phonematic hearing and working memory in infants and children" (head: Prof. Włodzisław Duch). The project is funded by the Polish National Science Centre (DEC-2013/08/W/HS6/00333, Symfonia 1).

## REFERENCES

1. Bray N, Noyes J, Edwards RT, Harris N. Wheelchair interventions, services and provision for disabled children: a mixed-method systematic review and conceptual framework. *BMC Health Serv Res.* 2014;14:309.
2. Travlos V., Patman S., Wilson A., Simcock G., Downs J. Quality of life and psychosocial wellbeing in youth with neuromuscular disorders who are wheelchair users: A systematic review. *Arch Phys Med Rehabil.* 2016; doi: 10.1016/j.apmr.2016.10.011.
3. Elboim-Gabyzon M., Atun-Einy O., Khoury-Assaf I. Early use of power wheelchair for children with Duchenne muscular dystrophy: a narrative review. *Disabil Rehabil.* 2016; 9:1-9.
4. Livingstone R., Field D. Systematic review of power mobility outcomes for infants, children and adolescents with mobility limitations. *Clin Rehabil.* 2014;28(10):954-64.
5. Nooijen C. F., de Groot J. F., Stam H. J., van den Berg-Emons R. J., Bussmann H. B.; Fit for the Future Consortium. Validation of an activity monitor for children who are partly or completely wheelchair-dependent. *J Neuroeng Rehabil.* 2015;12:11.
6. O'Brien T. D., Noyes J., Spencer L. H., Kubis H. P., Hastings R. P., Edwards R. T., Bray N., Whitaker R. 'Keep fit' exercise interventions to improve health, fitness and well-being of children and young people who use wheelchairs: mixed-method systematic review protocol. *J Adv Nurs.* 2014;70(12):2942-51.
7. Eather N., Morgan P. J., Lubans D. R. Improving health-related fitness in children: the Fit-4-Fun randomized controlled trial study protocol. *BMC Public Health.* 2011;11:902.
8. Mikołajewska E. *Wózki dla osób z niepełnosprawnością ruchową.* FEM, Bydgoszcz 2016.
9. Poranen-Clark T, von Bonsdorff MB, Lahti J, Rääkkönen K, Osmond C, Rantanen T, Kajantie E, Eriksson JG. Infant motor development and cognitive performance in early old age: the Helsinki Birth Cohort Study. *Age* 2015;37(3):9785.
10. Akdemir D, Pehlivan Türk B, Unal F, Ozusta S. Comparison of attachment-related social behaviors in autistic disorder and developmental disability. *Turk Psikiyatri Derg.* 2009;20(2):105-17.
11. Rendeli C, Salvaggio E, Sciascia Cannizzaro G, Bianchi E, Caldarelli M, Guzzetta F. Does locomotion improve the cognitive profile of children with meningomyelocele? *Childs Nerv Syst.* 2002;18(5):231-4.
12. Makiełło-Jarzowa G, Gerc K. Psychological consequences of neurologic motor impairment from a developmental perspective. *Przegl Lek.* 1998;55(4):198-202.
13. Klasik A, Janas-Kozik M, Krupka-Matuszczyk I, Augustyniak E. Cognitive functions, their development and modern diagnostic methods. *Przegl Lek.* 2006;63 Suppl 1:29-34.
14. Frolek Clark GJ, Schlabach TL. Systematic review of occupational therapy interventions to improve cognitive development in children ages birth-5 years. *Am J Occup Ther.* 2013;67(4):425-30.
15. Mikołajewska E., Mikołajewski D. Aplikacje mobilne w diagnostyce i terapii dzieci. *Przegl. Pediatr.* 2016;45(1):32-38.
16. Komendziński T., Mikołajewska E., Mikołajewski D., Dreszer J., Bałaj B. Cognitive robots in the development and rehabilitation of children with developmental disorders. *Bio-Algorithms Med-Systems* 2016; 12(3):93-98.
17. Mikołajewska E., Mikołajewski D., Komendziński T., Dreszer-Drogorób J., Bałaj B. Robot-mediated pediatric neurorehabilitation. *J. Health Sci.* 2014;4(2):91-96.

18. Mikołajewska E., Mikołajewski D., Komendziński T. Wykorzystanie zabawek w rehabilitacji neurologicznej dzieci. *Niepełnosprawność Rehab.* 2014;14(2):119-129.
19. Mikołajewska E., Komendziński T., Dreszer J., Bałaj B., Mikołajewski D. Tytuł oryginału: Role of toys in the development and rehabilitation of children with developmental disorders. *Czasopismo: J. Educ. Health Sport* 2015;5(4):224-228.

Address for correspondence:

dr Emilia Mikołajewska  
Department of Physiotherapy  
Ludwik Rydygier Collegium Medicum  
Nicolaus Copernicus University  
ul. Jagiellońska 13-15  
85-094 Bydgoszcz  
Poland  
e-mail: e.mikolajewska@wp.pl, emiliam@cm.umk.pl

Received: 2.11.2016

Accepted for publication: 16.12.2016