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INNOVATION DESIGN OF ASSISTIVE DEVICES TO IMPROVE MOTOR SKILLS IN PHYSICAL DISABILITIES

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Abstract

This research aims to develop an innovative therapy tool called "BPW" (Boardwalk, Parallel Bar, and Wall Bar) to improve motor skills in individuals with cerebral palsy diplegia. The research method used is the research and development (R&D) model with the ADDIE framework (analysis, design, development, implementation, and evaluation), which includes combining three therapy tools in one innovative tool. The results showed that the "BPW" tool provides various advantages, including improved balance, stability, and motor skills of children with diplegia cerebral palsy, as well as ease of use and space and cost efficiency, because it is designed to be easily adapted to the needs of each user and reduce the risk of injury. The innovation of the "BPW" tool is expected to be a practical solution in physical therapy, maximizing the effectiveness of motor training, as well as supporting long-term rehabilitation in children with cerebral palsy diplegia.

Keywords: Cerebral palsy, Innovative therapy tool, Motor ability, Motor skill, Physical disability.

1. Introduction

The need for innovative therapeutic aids for individuals with physical disabilities, especially children with cerebral palsy, encourages researchers to explore new innovations in accordance with existing developments. Cerebral palsy is a physical disability that generally occurs in childhood and can affect motor skills and posture. One of the most common forms of cerebral palsy is cerebral palsy diplegia, which causes weakness in all four limbs, with greater inhibition in the lower extremities [1]. This condition often hinders a child's ability to walk, maintain balance and perform daily physical activities, all of which stem from impaired motor function due to muscle imbalance and suboptimal postural control [2]. In an effort to improve gross motor skills, various therapeutic tools such as boardwalks, parallel bars and wall bars, have been used. However, these tools are often less effective due to limitations in terms of space use efficiency, practicality, and adaptability to user needs and abilities. This encourages the formation of innovative therapeutic tools that can increase the effectiveness of rehabilitation and maximize the potential of children with diplegia cerebral palsy.

The use of innovative therapy tools has been shown to be able to increase the efficiency and effectiveness of therapy, especially in learners with cerebral palsy diplegia which emphasizes the importance of innovation in therapy tools to maximize the goals to be achieved [3]. Previous research has shown that the use of assistive devices such as boardwalks, parallel bars and wall bars have an important role in improving motor skills in individuals with motor impairments. The use of these tools not only strengthens muscles, but also helps improve balance, coordination, as well as postural control [4-7]. The use of this tool is also effective to be used safely and structured, so that children with diplegia cerebral palsy can maximize their movement potential, especially in various physical activities that focus on motor development.

This research aims to develop an innovative therapy tool “BPW” (Boardwalk, Parallel Bar, Wall Bar) that combines the three tools into one device. This innovation is expected to improve gross motor skills, balance, and stability of children with diplegia cerebral palsy so that motor learning becomes more effective. With the “BPW” tool, motor therapy is expected to be more efficient and accessible, both for therapists, teachers, and families, so as to improve the motor skills of children with diplegia cerebral palsy.

2. Literature Review

Cerebral palsy is an obstacle that affects brain development in a foetus or infant which causes limited activity, movement and posture [8, 9]. Cerebral palsy diplegia is a condition of cerebral palsy with more dysfunction in the lower extremities than the upper extremities caused by developmental barriers in the brain responsible for control and coordination of movement, so individuals with cerebral palsy diplegia often have difficulty walking, controlling leg movements, and maintaining posture. [10, 11]. The part of the brain that affects the condition of cerebral palsy diplegia is described in Fig. 1.

Based on these conditions, one of the most influential in daily activities is motor skills. The role of motor skills is related to movement, including the use of large muscles and small muscles by involving three aspects namely muscles, nerves and the brain which can be developed especially during childhood which is divided into

two namely fine and gross motoric [12, 13]. In moving or doing daily activities is the role of gross motor by using large muscles, with some of the activities carried out are walking, running, jumping, throwing [14, 15]. Gross motor affects how a person does activities, so training is needed to improve it [16].

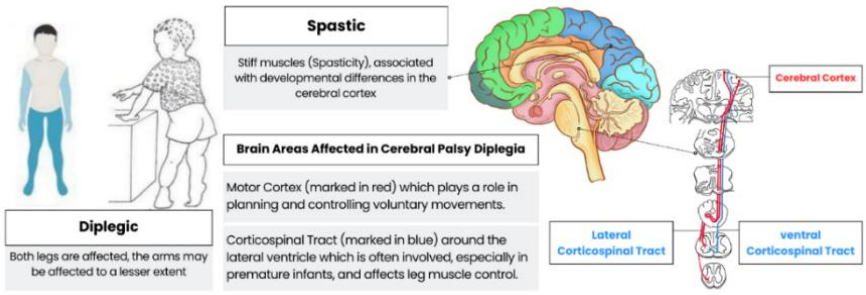

Fig. 1. Cerebral palsy diplegia.

In doing the exercise, of course, tools are needed as an auxiliary medium that facilitates the skills to be developed. For children with cerebral palsy diplegia, tools that play an important role are boardwalks, parallel bars and wall bars. The boardwalk itself is a tool used to train balance, coordination, and motor skills with a narrow and long bridge shape that trains balance and body control to walk on an unstable surface [17, 18]. Parallel bars have a role for children with cerebral palsy diplegia, who often have difficulty walking, maintaining balance, and coordination. This tool consists of two parallel bars mounted at a certain height to stimulate motor skills and balance in walking [19, 20]. The last one is the Wall bar, which is a ladder-shaped tool and is mounted on the wall in a vertical position. This tool helps in the development of motor skills and balance [21]. By using these three tools, children with diplegia cerebral palsy can perform exercises that focus on improving leg mobility, flexibility, and postural alignment [22].

3. Method

The method used in research innovation is research and development (R&D) to produce innovative products in the form of "BPW" (Boardwalk, Parallel Bar, and Wall Bar) tools. The model used is ADDIE with five stages, namely: Analyse, Design, Development, Implementation, and Evaluation [23]. This research was conducted up to the development stage through innovation using the "BPW" tool (Boardwalk, Parallel Bar, and Wall Bar) in improving motor skills in children with cerebral palsy diplegia.

4. Results and Discussion

This research analyses the needs and components of the innovative "BPW" tool by identifying the specific needs of individuals with physical disabilities, especially those with cerebral palsy diplegia. This is done by assessing initial motor skills, physical constraints, and expected goals. Furthermore, the results of the child's needs analysis were identified using supporting literature to find out the motor skills that need to be developed by children with cerebral palsy diplegia. In supporting this analysis, the process was continued with interviews with

practitioners, direct observation, and the use of evaluation tools such as the gross motor function classification system-extended and revised version (GMFCS-ER) and the Modified Ashworth Scale. The results of interviews with practitioners stated that boardwalks, parallel bars and wall bars have an important role to improve balance, stability, coordination and motor skills in children with cerebral palsy diplegia. This tool is used alternately and requires a wider place to use all three. So that in its implementation, the three tools are not used optimally because they are less efficient.

The next step is the development of innovative "BPW" tools to improve motor skills in children with diplegia cerebral palsy by conducting expert validation to find out whether the innovative tools developed are in accordance with the needs of children with diplegia cerebral palsy. Based on the results of the analysis that has been carried out, the tool design is developed to adjust the design where the three tools developed, namely the boardwalk, parallel bar and wall bar can be combined and easily used in one tool. The prototypes of the three tools are arranged in the form of model designs by adjusting the size, media or materials used, and an innovative description of the tools to be developed. The process of developing the "BPW" innovation tool is based on the need to use three tools to improve motor skills, namely the boardwalk, parallel bar and wall bar. The stages for the development process are presented in Fig. 2. In achieving the goals of the "BPW" tool innovation, the design must meet four requirements, namely (i) easy to operate by one person; (ii) can be used in a limited space; (iii) comfortable to use by children with diplegia cerebral palsy; and (iv) flexible to use anywhere. The design has two main features, which are easy to fold and adapted to the needs and achieve these goals. Namely, the stairs can be folded, and the parallel bars are in the form of disassembly.

In the innovative use of the "BPW" tool, it must be placed on a flat plane and close to the wall, first the ladder will be pulled upwards so that it has a vertical shape with the wall as a support. The material used to make the stairs is wood with five steps. The size of the slope of the stairs can be adjusted to the needs of children with diplegia cerebral palsy by adjusting the distance between the wall and the innovation of the "BPW" tool, the farther the position with the wall, the more the slope of the stairs decreases. Furthermore, the parallel bar is assembled by attaching a stainless-steel handle to the existing tool, in the process the connecting lever must be installed tightly by turning the existing lever. The height of the parallel bar can be adjusted and adjusted to the height of the cerebral palsy diplegia child so that the child feels comfortable using the tool. The maximum height of the parallel bar tool is 100 cm. The use of boardwalks is carried out on a wooden plane in the middle of the parallel bar to help cerebral palsy children walk straight with a maximum distance of 140 cm or 10 cm before the wall bar. The picture of the innovation tool "BPW" is thoroughly illustrated in Fig. 3. The use of the boardwalk can also utilize the existing parallel bar, so that when the child is not yet able to walk far, they can reach the handle of the parallel bar. Furthermore, Fig. 4 describes the dimensions of the entire tool.

Fig. 2. Manufacturing steps of the "BPW" tool innovation.

Fig. 3. Innovation of the "BPW" tool.

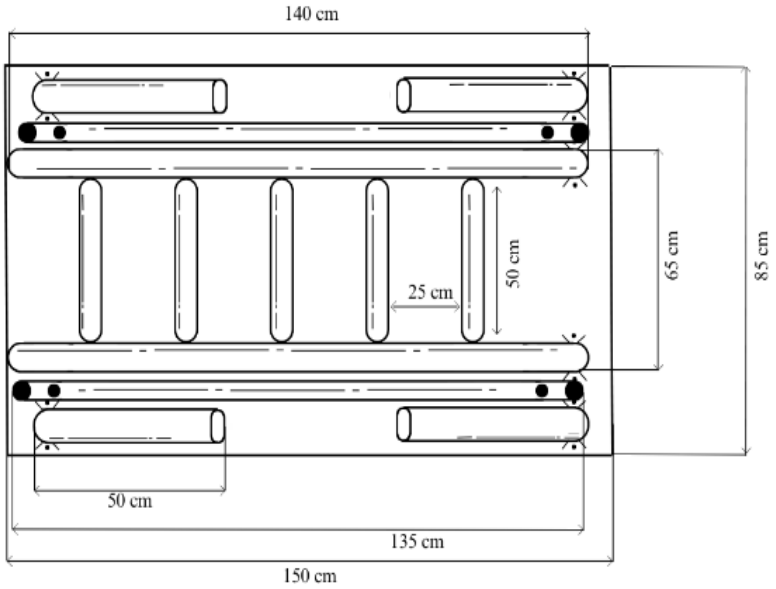

Fig. 4. Dimensions of the entire tool.

In this tool innovation, the number of boards used is two boards by adjusting the ability of children with diplegia cerebral palsy. This size is based on the abilities of children with diplegia cerebral palsy, but in some conditions the size of the basic "BPW" tool is adjusted again based on the child's abilities and needs. Without the incorporation of this tool, in many cases the therapy tool is not used optimally because it only uses one of the media to improve motor skills for various reasons such as uneconomical, heavy, complicated to use, uncomfortable, not adjustable and so on. In using the innovative tool "BPW", parents, therapists, or teachers feel the many benefits obtained. The advantages of using the "BPW" tool are described in Table 1.

Table 1. Advantages of using the "BPW" tool.

Advantages	Information
Innovation of Therapy Tool Integration	The use of therapy tools in the form of innovations that can improve the efficiency and effectiveness of therapy for learners with cerebral palsy diplegia [24]. One example of an innovative tool is incorporating rehabilitation technology to increase learner participation. Appropriate innovations can help learners to train well.
Practical	Innovative tools that are practical help in improving overall goals [25]. Currently, tools for physical exercise are not practical for use in routine training, especially for cerebral palsy learners who need a variety of assistive devices [26]. With the innovation of BPW, it can help combine three tools into one so that it is more practical.
Motor Enhancement	Motor skills need to be trained for cerebral palsy learners, Boardwalk, Parallel Bar and Wall bar assistive devices help in improving motor skills [27]. Combining the three tools helps to maximize the motor improvement of learners with diplegia cerebral palsy [28].
Efficiency	Combining three tools into one makes the implementation of therapy more efficient, both in cost expenditure and space when used as a daily necessity.
Tool Customization	Making tools that are tailored to the needs of cerebral palsy diplegia helps meet the needs because they can be made and designed according to the capabilities of each user. Some tools are heavy, cumbersome to use, uncomfortable and not customizable [28], which led to the creation of this tool innovation.
Easy of use	The "BPW" tool innovation has a design that is easy to use compared to the use of each tool that must be prepared. By using the "BPW" tool, the transition between motor, balance and stability training without the need to move students to the location of the tool [28].
Injury Risk Reduction	The design of tools that have been adapted to the needs of children with cerebral palsy, especially in motor limitations, helps reduce the risk of injury that occurs due to moving children from one tool to another.

5. Conclusion

This research develops an innovative therapy aid "BPW" (Boardwalk, Parallel Bar, and Wall Bar) that helps in improving motor skills in individuals with diplegia cerebral palsy. This tool was developed using the ADDIE model until the development stage. The results showed that the "BPW" tool not only improved the balance, stability, and motor skills of children with cerebral palsy, but also offered ease of use, space and cost efficiency, and reduced risk of injury. Its flexible design makes it easy for the device to be customized to each user's needs. This innovation is expected to be a solution in physical therapy, maximizing the effectiveness of motor training and can be further developed and applied for both therapy centres and personal use.

References

1. Ali, M.S. (2021). Does spasticity affect the postural stability and quality of life of children with cerebral palsy? *Journal of Taibah University Medical Sciences*, 16(5), 761-766.
2. Hides, J.A.; Donelson, R.; Lee, D.; Prather, H.; Sahrmann, S.A.; and Hodges, P.W. (2019). Convergence and divergence of exercise-based approaches that incorporate motor control for the management of low back pain. *Journal of Orthopaedic and Sports Physical Therapy*, 49(6), 437-452.
3. Apolo-Arenas, M.D., Jerônimo, A.F.D.A., Caña-Pino, A., Fernandes, O., Alegrete, J., and Parraca, J.A. (2021). Standardized outcomes measures in physical therapy practice for treatment and rehabilitation of cerebral palsy: A systematic Review. *Journal of Personalized Medicine*, 11(7), 604.
4. Ungureanu, A.; Rusu, L.; Rusu, M.R.; and Marin, M.I. (2022). Balance rehabilitation approach by bobath and vojta methods in cerebral palsy: A pilot study. *Children*, 9(10), 1481.
5. Dewar, R.; Love, S.; and Johnston, L.M. (2015). Exercise interventions improve postural control in children with cerebral palsy: A systematic review. *Developmental Medicine and Child Neurology*, 57(6), 504-520.
6. Galeano, D.; Brunetti, F.; Torricelli, D.; Piazza, S.; and Pons, J.L. (2014). A tool for balance control training using muscle synergies and multimodal interfaces. *BioMed Research International*, 2014(1), 1-13.
7. Low, D.C.; Walsh, G.S.; and Arkesteijn, M. (2017). Effectiveness of exercise interventinons to improve postural control in older adults: A systematic review and meta-analyses of centre of pressure measurements. *Sports medicine*, 47, 101-112.
8. Emara, H.A.M.A.H. (2015). Effect of a new physical therapy concept on dynamic balance in children with spastic diplegic cerebral palsy. *Egyptian Journal of Medical Human Genetics*, 16(1), 77-83.
9. Jin, S.; Lewis, S.; Bakhtiari, S.; Zeng, X.; Sierant, M.; Shetty, S.; Nordlie, S.; Elie, A.; Corbett, M.; Norton, B.; and van, E. (2020). Mutations disrupting neuritogenesis genes confer risk for cerebral palsy. *Nature Genetics*, 52(10), 46-56.
10. Jeong, Y.A, and Lee, B.H. (2020). Effect of action observation training on spasticity, gross motor function, and balance in children with diplegia cerebral palsy. *Children* (*Basel*), 7(6), 64.
11. Vitrikas, K.; Dalton, H.; and Breish, D. (2020). Cerebral palsy: An overview. *American Family Physician*, 101(4), 213-220.
12. Saputri, G.R.; Sasmiati, S.; and Sofia, A. (2017). Frekuensi latihan senam irama dan perkembangan motorik kasar anak usia dini. *Jurnal Pendidikan Anak*, 3(2), 35-41.
13. Manggau, A.; and Usman, A. (2020). Developing the gross motor skills of children by simultaneously training them with rhythmic gymnastics. *Journal of Educational Science and Technology*, 6(2), 205-206.
14. Sutapa, P.; and Suharjana, S. (2019). Improving gross motor skills by gross kinesthetic-and contemporary-based physical activity in early childhood. *Jurnal Cakrawala Pendidikan*, 38(3), 540-551.

15. Logan, S.W.; Ross, S.M.; Chee, K.; Stodden, D.F.; Robinson, L.E. (2018). Fundamental motor skills: A systematic review of terminology. *Journal of Sports Sciences*, 36(7), 781-796.
16. Bakaniene, I.; Urbonaviciene, G.; Janaviciute, K.; and Prasauskiene, A. (2018). Effects of the inerventions method on gross motor function in children with spastic cerebral palsy. *Neurol Neurochir Pol*, 52(5):581-586.
17. Viratia, V.; Kumar, S.; Praveen, S.; and Shrivastava, T. (2022). Enhancing trunk control balance in children with spastic diplegic cerebral palsy: Comparative effectiveness of the vestibular stimulation technique and standard treatment. *The Scientific Temper*, 13(02), 309-316.
18. Alizamani, S.; Ghasemi, G.; and Nejadian, S.L. (2023). Effects of eight week core stability training on stable-and unstable-surface on ankle muscular strength, proprioception, and dorsiflexion in athletes with chronic ankle instability. *Journal of Bodywork and Movement Therapies*, 34, 6-12.
19. Mirin, S.N.S.; Mohsin, T.M.M.; and Annuar, K.A.M. (2019). Flexible parallel bar for physiotherapy purposes. *International Journal of Human and Technology Interaction* (*IJHaTI*), 3(1), 55-64.
20. Moon, D.H.; Park, C.H.; Moon, M.H.; Park, H.J.; and Lee, S. (2020). The effectiveness of double-bar correction for pectus excavatum: a comparison between the parallel bar and cross-bar techniques. *Plos One*, 15(9), 1-9.
21. Komisar, V.; McIlroy, W.E.; and Duncan, C.A. (2019). Individual, task, and environmental influences on balance recovery: A narrative review of the literature and implications for preventing occupational falls. *IISE Transactions on Occupational Ergonomics and Human Factors*, 7(2), 91-118.
22. Abd-Elfattah, H.M.; Galal, D.O.S.M.; Aly, M.I.E.; Aly, S.M.; and Elnegamy, T.E. (2022). Effect of pilates exercises on standing, walking, and balance in children with diplegic cerebral palsy. *Annals of Rehabilitation Medicine*, 46(1), 45-52.
23. Spatioti, A.G.; Kazanidis, I.; Pange, J. (2022). A comparative study of the ADDIE instructional design model in distance education. *Information*, 13(9), 402.
24. Whittingham, K.; Sheffield, J.; Boyd RN. (2016). Parenting acceptance and commitment therapy: A randomised controlled trial of an innovative online course for families of children with cerebral palsy. *BMJ Open*, 6(10), 1-7.
25. Jackman, M.; Sakzewski, L.; Morgan, C.; Boyd, R.N.; Brennan, S.E.; Langdon, K.; Toovey, R.A.M.; Greaves, S.; Thorley, M.; and Novak, I. (2022). Interventions to improve physical function for children and young people with cerebral palsy: International clinical practice guideline. *Dev Med Child Neurol*, 64(5), 536-549.
26. Verschuren, O.; Hulst, R.Y.; Voorman, J.; Pillen, S.; Luitwieler, N.; Dudink, J.; and Gorter, J.W. (2021), 24-hour activity for children with cerebral palsy: A clinical practice guide. *Dev Med Child Neurol*, 63(1), 54-59.
27. Prabandari, N.I.; and DINI, P.I.A.U. (2019). Pengaruh kegiatan fisik motorik berjalan di atas papan titian terhadap keseimbangan tubuh anak kelompok A Di Tk kuntum Surabaya. *Αγαη*, 8(5), 55.
28. Khalid, K.; Naveed, A.; Mehwish, S.; Riffat, A.G.; Muhammad, I.A.; Ashfaq, A. (2020). Current physical therapy practices and parental satisfaction for rehabilitation services of cerebral palsy children. *Rawal Medical Journal*, 45(3), 586-589.