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by Agung Kristanto

Adaptable Ergonomic Interventions for Patients with Cerebral Palsy to Rice Farmers Activities: Reviews and Recommendations

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Abstract

People with cerebral palsy (CP) are functionally restricted to differing degrees due to a decrease of main control and coordination of movements. Although inherently different in causation, a previous study demonstrated that physical disabilities faced by CP patients might also be experienced by rice farmers due to the risky working environment and unsafe working posture. Research on assistive technology (AT) for CP population was extensively conducted, whereas AT studies for preventing farmer disadvantage were limited. Certain ATs developed for patients with CP might also be benefit to healthy rice farmers exposed to extreme working environments to prevent occupational injuries. This article provides a constrained review of available ergonomic interventions for patients with CP disability that bear prospect to be applicable to rice farmers. All papers were retrieved from the last 20-years collection from nine major search engines, including: "Scopus", "Web of Science", "CINAHL", "Cochrane Database of Systematic Reviews", "Education Source", "ERIC", "Journals@OVID", "MEDLINE", and "PASCAL". Specified terms of "ergonomic interventions", "congenital disability", "cerebral palsy", and "orthoses" were used as search keywords. Two independent reviewers defined whether the articles complied to the inclusion criteria of: (1) a review or the next best available; (2) contains ergonomic interventions; and (3) more than 25% of participants were persons with CP. So far, there were 21 articles relating to the research of ergonomic interventions for people with CP. The interventions studied in those articles were categorized as: (1) engineering, (2) administrative and, (3) behavioral interventions. Detailed discussions regarding to adaptability of each intervention were then provided in terms of capability for assistance, improvement and prevention of MSD problems. Most studies reported engineering and administrative interventions to significantly improve motor function and gait characteristics. Behavioral interventions successfully promoted positive mood and behavior, as well as reduced stress and oppositional behavior. Types of intervention for CP patients that might be adaptable for farmers were discussed, along with related examples that had been proposed for reducing risk of injury among paddy field farming workers. In general, the findings indicated most adapted interventions were based on educational programs, with no attempt to adapt engineering interventions from CPs for farmers. We recommended that a certain combination of engineering and administrative interventions for CPs treatment, with slight modifications, may be applicable to farmers for preventing risky environmental conditions and unsafe working postures.

Keywords: Ergonomic interventions, Congenital disability, Cerebral palsy, Paddy field farming

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1. Introduction

Disability can be generally divided into two main groups based on the causation, namely congenital disabilities and circumstantial disabilities [1]. Congenitally disabled people with cerebral palsy (CP) display a walking-related disability or muscular weakness, which is often caused by upper neuron disorders [2]. Previous studies indicated that certain characteristics of the working environment can potentially render healthy workers to have performances comparable to that of disabled people. It was also noted that indirect disabilities induced by various work-related tasks may possibly lead to physical and cognitive conditions resembling congenital disabilities [1 & 3]. With this possible association, muscle injury encountered by CP patients might, also be developed by rice farmers due to the unsafe work posture and environmental conditions experienced while paddy field [4].

The most common tasks during rice cultivation in Asian countries are still performed in a traditional fashion, involving awkward work posture and harsh environmental conditions. Typical examples for such processes of paddy field farming include plowing, seeding, planting, nursing, fertilizing and harvesting [5]. Notably, almost all stages of paddy farming involve repetitive motions, uncomfortable postures, heavy lifting and carrying, prolonged standing, and control of heavy and vibrating machinery [6]. Specifically, the plowing task is conducted by using a heavy vibrating plowing machine, while the seeding, nursing, and fertilizing activities implicate heavy lifting and carrying. The planting stage involves repetitive forward trunk bending and twisting and prolonged stooping and walking is required during harvest. All these tasks clearly represent risk factors for biomechanical malfunction and chronic musculoskeletal disorders (MSDs) [6], which is further emphasized by a previous study reporting the rate of occurrence for MSDs among Thai rice farmers ranging between 10.3-73.3% [7]. In addition, a high prevalence for foot pronation and knee valgus has been found with percentages of 20.9% and 18.5%, respectively [8]. This situation is exacerbated by the preference of farmers to perform their work with bare feet, since the muddy work environment in the paddy field has previously been found to increase force loading on foot and knee joints and muscles due to adverse effects of ground viscous force [4]. However, the development of technological interventions protecting workers, in particular rice farmers, from extreme occupational harm are still rare and limited [9 & 10].

A previous study revealed preliminarily evidence that both rice farmers and CP patients are potentially related in terms of perceived foot and knee soreness and MSDs injuries [11]. Although inherently different in causation, physical disabilities typically associated with CP patients, including knee and foot muscles and joints damage, were also experienced by rice farmers due to the risky environment and unsafe working posture (see detailed investigation in [11]). Likewise, a similarity between the standing posture of CP patients and that of rice farmers during the performance of cultivation activities has been observed, as both population were found to have a high prevalence of knee valgus and foot pronation. Therefore, knee and foot injuries and MSDs should be the main focus of intervention designs in order to avoid the potential risk of lower extremity (LE) harm for paddy farmers. Such interventions could potentially be based on assistive technology previously developed for the CP population. Non-occupational disabilities research can be used as a solid basis for assistive technology (AT) development studies for the agricultural workforce, as available AT designs for the disabled population are already widely available in the commercial market (e.g., back braces, foot orthotics, leg braces, wheelchair, etc.) A broad range of research with focus on AT development for people with disabilities has already been conducted which could also benefit healthy workers exposed to extreme working environments to ease daily life activities or prevent occupational-related injuries (e.g., [12]).

This article aims to provide a constrained review of available interventions for CP disabled people that could be applicable to rice farmers. Ergonomic interventions reviewed in this article were categorized into: (1) engineering, (2) administrative and (3) behavioral control measures [13]. Engineering interventions involve designing systems, equipment or process for eliminating or reducing exposure to dangers (i.e., combining engineering controls and personal protective equipment in the traditional ergonomic/safety preventive measures [14]). Administrative interventions focus on controlling procedures and work practices for example work rotation, task units, and policies. Behavioral interventions, separated from traditional administrative controls in this article, as they concentrate on modifying personal behaviors, which includes behavior support and stress management [13]. Subsequent section provided detailed discussions regarding to adaptability of each intervention in terms of assistance capability, ability improvement and MSD prevention. The intervention types of CP population that might be applicable for farmers were then discussed, along with related intervention examples that had been proposed for reducing risk of injury among paddy field farming workers.

2. Material and Method

In this study, we focused on the literature regarding ergonomic interventions for CP patients. A constrained review was performed using nine article databases, including: "Scopus", "Web of Science", "CINAHL", "Cochrane Database of Systematic Reviews", "Education Source", "ERIC", "Journals@OVID", "MEDLINE", and "PASCAL". Specified terms of "ergonomic interventions", "congenital disability", "cerebral palsy", and "orthoses" were used as search keywords in this study. In the first stage, we recognized 256 pertinent manuscripts which were further refined by the restrictions of being in English language and published within the last 20 years.

Subsequently, two independent reviewers defined whether the articles complied to the inclusion criteria of: (1) the article was a review or the next best available; (2) it contained of ergonomic interventions; and (3) more than 25% of participants were persons with CP. Ergonomic interventions were categorized into control measures involving adjusting workers' environment, tools, work methods and behavior, as well as long-term educational/training approaches to treat and prevent further damage due to MSDs [15]. Finally, after in-depth analysis of abstract and full text articles, 21 articles were included in this study. These comprise 8 papers from Scopus, 4 papers from Web of Science, 4 papers from CINAHL, and 5 papers from MEDLINE. No papers were met the inclusion criteria in Cochrane, Education Source, ERIC, Journals@OVID, and PASCAL. The whole screening and acceptance process is described in Figure 1.

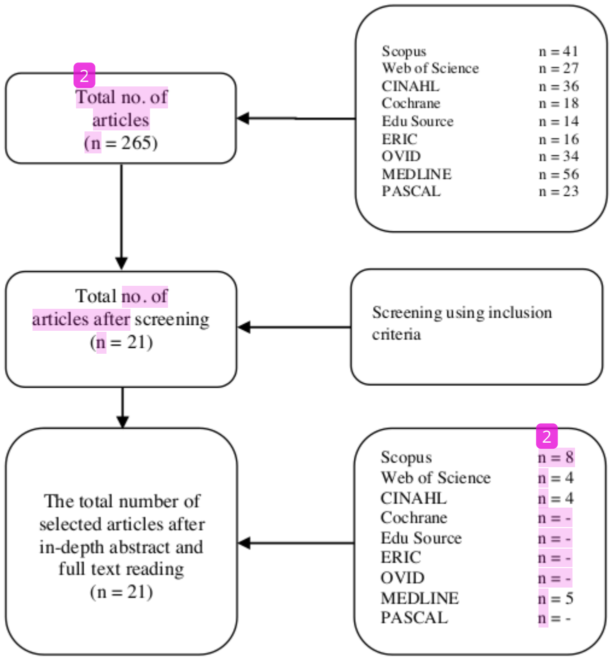

Figure 1 Article screening process

3. Results and Discussion

Selected papers focused on ergonomic interventions for people with CP were reviewed in detail. The results in brief are shown on Tables 1 to 3. Although the prior research showed that farmers and CP patients share similar problems at foot and knee regions, the present review was conducted for the whole body, since some interventions might be adaptable to lower limb parts.

The following subsections discuss interventions for people with CP that could also be applied by healthy rice farmers working in extreme environment to prevent or treat occupation-related injuries. Subsequently, a similar literature search was conducted for interventions that had previously been proposed for rice farmers. Specified terms of “ergonomic interventions”, “rice”, and “paddy” were used as search keywords. Table 4 shows the interventions developed for CP patients that might be adaptable for rice farmers, along with related examples that had been proposed in previous studies.

3.1 Engineering Interventions

Adaptive devices have been shown to be effective in both disabled and aging population [16]. Adaptive devices successfully assist people with disability in functional problems, including difficulty with activities of daily living (ADLs), as evidenced by high percentage improvement of desired outcomes. However, most devices were designed for home use or with environmental modifications (e.g., ramps). Therefore, adaptive devices might not be suitable for the environmental conditions in a paddy field.

Orthotic devices, including casted orthoses, have been demonstrated to successfully enhance the range of motion (ROM) of the lower extremities [17 &18]. However, this type of orthosis is also associated with some adverse effects, including: high price, time-consuming production, difficulty to fit into footwear, skin irritation, foot and calf pain, cast breakdown, and continuing impairment conditions [18,37-39]. Removable external orthotic devices, such as knee braces, ankle foot orthoses (AFO) and knee ankle foot orthoses (KAFO), are generally used to control movement, provide an opposing force, and support ineffective joints or muscles [19]. Previous research found braces to improve gait parameters as compared with standard treatment [19]. However, conventional rigid designs restrict movement as they keep the knee and ankle in a fixed position to provide stability during walking [40]. More recent designs include adaptive control for joint restriction using pneumatic or electric actuators [20]. However, these are costly, often complicated, and need an external power source [41]. Simple corrective insoles are less expensive and require significantly less time to produce [42]. Previous research showed the corrective insoles to be successfully tested for the treatment of flexible flatfoot [43] and reduction of foot eversion in footwear that has restricted space [44].

Breathable orthotic garment, such as TheraSuit [21], is another possible intervention that has been found to help improve gross motor function without any serious safety issues or skin abrasions reported during the treatment [21]. The suit was originally designed to be worn with bungee cords; however, the additional cords did not add any benefit when compared with wearing the suit alone [21]. Although the suit might provide only small percentage of improvement, noncompulsory requirement of supportive cords contributes a mobility of the device. Therefore, it might represent a possible intervention applicable to farmers performing field work.

Seating and positioning devices enable a person with CP to sit in a comfortable posture and help improving postural control in general [22]. A variant of the device comprising an air inflated seat has been introduced to farmers for postural control during the harvesting process [45].

3.2 Administrative Interventions

Educational programs and training, such as manual training, conductive education, and early intervention, developed and successfully improved motor performance and safety for CP patients, may also be applied to rice farmers [23-25]. Regarding the educational programs, prior research [46 & 47] proposed to impart appropriate knowledge and control for safe rice farming work. Health education, as part of the Injury and Illness Preventive (IIP) intervention program [46], was conducted to support risk awareness and to provide safe work conditions during rice field farming. Training provided knowledge regarding work-related injury and illness, and ergonomic guidelines at work (e.g., appropriate work posture, material handling, tool use and working environment). Another part of the IIP program, safety inspection, included a training for inspecting equipment safety and working conditions, in order to help farmers to be able to recognize unsafety behaviors and working environment.

Goal-directed functional training [26] using a motor learning approach might also be beneficial to rice farmers similar to the approach used for CP patients. A previous study reported medium effect size of improvement when comparing goal-directed functional training and physical therapy based on normalization of the quality movement [26]. In a simulated paddy field plowing task, the researcher [48] found experienced farmers to generate higher grip force, to use and balance muscles more effectively, and display a lower fatigue rate, as compared to novice farmers. It was suggested to develop motor learning training for farmers to achieve effective muscle use and minimize risk of injuries.

Fitness and strength training found to significantly improve and maintain physical fitness and muscle strength for CP patients, when compared with regular physical therapy sessions [31& 32]. These specific training programs were also proved to help increasing muscle endurance and physical function, as well as reducing pain in rice farmers with chronic low back pain [49]. Simple physical exercises during the normal work schedule were also proved to reduce musculoskeletal pain [50] and improve the productivity [51]. Massage therapy also found to induce greater reduction in perception of pain and spasticity, as compared with a reading control group of CP patients [29]. Such corrective intervention might also alleviate pain experienced in rice farmers. In addition, manual stretching applied to CP patients to prevent muscle contracture [30], would be applicable to rice farmers. It was suggested to encourage farmers to perform simple stretching exercises during the lunch break. Furthermore, the application of massage therapy was suggested as a practical treatment to help relieve muscle pain and stiffness experienced by farmers [52] as in CP patients [29].

3.3 Behavioral Interventions

Caregivers successfully used animal assistance to improve patients' socialization and mood, reduce stress, and assist in ADLs [34]. In the rice cultivation context, paddy field preparation and the threshing process is sometimes conducted with the aid of farm animals [9-10, 53-54]. Besides use of farm animal assistance as low-cost and environment-friendly farming technique, the farmer's relationship with the animal contributes to the concept of social and economic sustainability [54]. In some communities, farm animals are sometimes given as a gift to relatives, friends or in marriage, and used in religious functions.

Behavior therapy, developed to support positive behavior in children with CPs [35], was identified as another form of possible interventions that could be adapted for promoting safety awareness and behavior for rice farmers. A previous study demonstrated considerable reduction of oppositional behavior of CP children when a family group actively participating in the therapy, as compared with a wait-list control group [35]. Safety communication, as part of the IIP program [46], applied risk communication processes to deliver information regarding possible occupational hazards, health effects and techniques for hazard prevention to rice farmers. Health surveillance programs required paddy field farming workers to report their injury or illness in order to identify the root cause of the incident.

Table 1 Reviews of selected articles - Engineering interventions

No	Intervention	Reference	Outcome
1	Assistive devices: equipment or devices to improve independence, such as walking frames, wheelchairs, adapted computer access	[16]	Improvement of desired outcomes in activities of daily living tasks (PDcontrol = 66%, PDintervention = 75%); slower decline in functional level of independent (PDcontrol = -3.4%, PDintervention = -1.8%)
2	Casting: plaster casts applied to limbs for muscle lengthening or reduce spasticity	[17 & 18]	Improvement of passive range of motion (ROM) of lower limbs and stride length
3	Orthotics: removable external devices designed to support weak or ineffective joints or muscles	[17, 19-20]	Improvement of stride length, ROM and walking distance (RPD =45%), and reduction of abnormal alignment (RPD = -1.1%)
4	Orthotic garments: breathable soft dynamic orthotic full body suit, designed to improve proprioception, reduce reflexes, restore synergies and provide resistance	[21]	Gross motor function improvement (PDcontrol, suit only = 5.9%, PDintervention, suit with supportive cords = 4.5%)
5	Seating and positioning: assistive device that enables a person to sit upright with functional, symmetrical or comfortable posture	[22]	Improvement of posture and postural control

Abbreviations: PD, percentage of difference from baseline; RPD, relative percentage of difference of control vs intervention.

Table 2 Reviews of selected articles – Administrative interventions

No	Intervention	Reference	Outcome
1	Manual training: repetitive task training in the use of one hand or two hands together	[23]	Hand function improvement; reduce time to complete Jebsen-Taylor Test of Hand Function (PDunimanual = -37.8%, PDbimanual = -34.5%)
2	Conductive education (CE): an educational classroom-based approach to teaching movement using rhythmic intention, routines and groups	[24]	Improvement of motor responses (percentage of participants that improved = 23-100%)
3	Early intervention (EI): therapy and early education to promote acquisition of milestones, via group or individual stimulus	[25]	Motor outcomes improvement
4	Goal-directed training/functional training: task specific practice of goal-based activities using a motor learning approach	[26]	Improvement of mobility of functional skill (effect size = 0.61)
5	Hip surveillance: active surveillance and treatment for hip joint integrity to prevent hip dislocation	[27]	Reduction of need for surgery on hip dislocation (requirement of reconstructive surgery reduced from 37.1% to 29%; and salvage surgery reduced from 11.4% to 0%)
6	Home programs: therapeutic practice of goal-based tasks by the child, led by the parent and supported by the therapist, in the home environment	[28]	Improvement of performance of functional activities
7	Massage: therapeutic stroking and circular motions applied by a massage therapist to muscles	[29]	Pain and spasticity reduction (PDcontrol = -9.1%, PDintervention =-33.3%)
8	Stretching: use of an external passive force exerted upon the limb to move it into a new and lengthened position	[30]	Improvement of joint ROM and functional ability
9	Fitness training: planned structured activities involving repeated	[31]	Aerobic fitness improvement (RPD =18-22% for short-term training; RPD = 26-

No	Intervention	Reference	Outcome
	movement of skeletal muscles that result in energy expenditure		41% for long-term training) and increase activity (RPD = 0-13% for short-term training; RPD = 2-9% for long-term training)
10	Strength training: use of progressively more challenging assistance to muscular contraction	[32]	Muscle strength improvement (effect size = 1.16 – 5.27)
11	Treadmill training: walking practice on a treadmill, with and without partial body support	[33]	Improvement of body structures and function, and gross motor function

Abbreviations: PD, percentage of difference from baseline; RPD, relative percentage of difference of control vs intervention.

Table 3 Reviews of selected articles – Behavioral interventions

No	Intervention	Reference	Outcome
1	Animal assistance: use of animals to give companionship and help with independence	[34]	Improvement of mood, behavior and self-perception
2	Behavior therapy: positive behavior support, behavior interventions, and positive parenting	[35]	Reduction of oppositional behaviors (PDcontrol = {-40}-20%, PDintervention ={-75}-{89.7}%)
3	Respite: temporary caregiving break for parents where the child is usually accommodated outside home	[36]	Reduction of life and parental stress

Abbreviations: PD, percentage of difference from baseline.

Table 4 Possible interventions of CP patients adaptable for rice farmers

Adaptable intervention	Related intervention proposed for rice farmers	Reference
Engineering intervention		
Orthotics	Not have yet implemented	
Orthotic garments	Not have yet implemented	
Seating and positioning	An air inflated pillow, like a floating seat in paddy field harvesting posture	[45]
Administrative intervention		
Bimanual training/ Conductive education/ Early intervention	Health education for rice farmer groups via the Injury and Illness Prevention (IIP) program	[46]
	Safety inspection for rice farmers via the Injury and Illness Prevention (IIP) program	[46]
	Model development for health promotion and control of agricultural occupation health hazards and accidents	[47]
Goal-directed training/ Functional training	Not have yet implemented	
Massage	Not have yet implemented	
Stretching	Not have yet implemented	
Fitness training/ Strength training	Intervention based on the Transtheoretical Model (TTM) on back muscle endurance, physical function and pain in rice farmers with chronic low back pain	[49]
Behavioral intervention		
Animal assistance	Paddy field preparation and threshing process were conducted by farm animals (e.g., buffalo, bullock)	[9-10,53-54]
Behavior therapy	Safety Communication for rice farmers via the Injury and Illness Prevention (IIP) program	[46]
	Health surveillance for rice farmer groups via the Injury and Illness Prevention (IIP) program	[46]

4. Conclusion

As farmers face severe ergonomic problems physically, assistive tools and proper work process design by considering the ergonomic perspective are urgently needed for MSD prevention in paddy farming workplaces. Farmers experience severe ergonomic problems; for example, MSDs, tool-related accidents and injuries, and lack of safety training. Ergonomic interventions are an effective method for micro-ergonomic occupational related problem prevention. Based on the literature review, engineering and administrative interventions, developed for CP patients, contributed to significantly improvement of motor function and gait characteristics. Behavioral interventions successfully promoted positive emotion and appropriate behavior, as well as reduced stress and oppositional behavior in CP patients. Discussions of adaptability of interventions revealed that a multitude of interventions developed for CP patients might be easily adapted to rice farmers. However, most of the proposed interventions for farmers are based on educational programs, which are closely related to administrative and behavioral interventions. Although in previous research engineering interventions had been developed through tool design for paddy cultivation, including seeding, planting, threshing and harvesting (e.g., [10],[55] and [56]), none of these approaches attempted to adapt already available interventions for congenital disabilities, including CPs, for farmers. Similarly, despite modern harvesting and planting machines have been introduced, limitations for widespread use of such mechanical power still persist, not least due to socio-economic conditions and infra-structural limitations of the society [45 & 57]. Based on interventions that have been applied for CP patients, orthotic devices and breathable orthotic garments might be applicable for rice farmers, however, have not yet been implemented in previous studies.

In summary, farmer interventions should emphasize on both tool design and educational programs. The following key points were recommended to prevent MSDs and improve occupational health and safety in the rice farming industry:

- Design and develop specific job descriptions according to ergonomic guidance;
- Design and develop assistive devices considering ergonomic guidance;
- Promote fitness and strength training, as well as design motor learning training for effective movement;

- Implement assessment tools and reviewing systems for MSD and injury prevention, as well as accident and risk factor reduction among rice farmers;
- Create supportive collaborations with involved farmers through intervention programs and assessments and;
- Support campaign for safety and health programs and drive rice farmers' awareness for work safety.

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6

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