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Artikel Ulasan/*Review Articles*

Postural Control Influence on Upper Extremity Function among Children with Cerebral Palsy: A Literature Review

(Pengaruh Kawalan Postur Terhadap Kefungsian Anggota Atas di Kalangan Kanak-kanak Palsi Serebral: Ulasan Literatur)

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ABSTRACT

Performance of upper extremity function and movement sequence is influenced by postural control. Motor disorders lead to deficits in postural control, which subsequently may lead to postural instability of children with cerebral palsy (CWCP). This will limit their upper extremity activity performance. Management strategies help to support and enhance the CWCP's upper extremity function so that they may engage with the activities of daily living. The purpose of this paper is to review previous literature on the influence of postural control towards upper extremity function. Literature searches were conducted in various electronic databases, including ProQuest, Science Direct, Springer Link, Sage, Wiley Online Library, and Google Scholar using specific key terms. Search terms included children with cerebral palsy; postural control; postural adjustments; upper extremity function; reaching and sitting and from references of retrieved articles. Nineteen journal articles published between 2000 and May 2015 were found. Most search results consisted of experimental studies, while others are reviews, case studies, and cross-sectional studies. Findings show that, postural control has a major influence on upper extremity function. In conclusion, it is necessary to highlight the importance of both factors to the CWCP parents or caregivers, as understanding and awareness on this matter is still inadequate in the community. Hence, a study is needed on the awareness of the postural control influence on upper extremity function among caregivers, as well as examining the implementation of management strategies in community settings.

Keywords: Children with cerebral palsy; postural control; postural adjustments; upper extremity function; reaching

ABSTRAK

Prestasi kefungsian anggota atas dan turutan pergerakan dipengaruhi oleh kawalan postur. Kecelaruan motor akan menyebabkan kelemahan pada kawalan postur, seterusnya membawa kepada ketidakstabilan postur kanak-kanak palsi serebral. Ini akan menghadkan prestasi aktiviti anggota atas. Strategi pengurusan didapati dapat membantu menyokong dan meningkatkan kefungsian anggota atas kanak-kanak palsi serebral supaya mereka dapat melibatkan diri dengan aktiviti harian. Tujuan kajian ini adalah untuk mengulas kajian lepas mengenai pengaruh kawalan postur terhadap kefungsian anggota atas. Carian literature telah dijalankan dalam pelbagai pangkalan data elektronik termasuk ProQuest, Science Direct, Springer Link, Sage, Wiley Online Library, dan Google Scholar menggunakan istilah spesifik. Istilah carian yang dimasukkan adalah kanak-kanak palsi serebral; kawalan postur; pengubahsuaian postur; kefungsian anggota atas; mencapai dan duduk serta dari rujukan artikel yang ditemui. Sembilan belas artikel jurnal yang diterbitkan di antara tahun 2000 dan Mei 2015 telah ditemui. Kebanyakan hasil carian terdiri daripada kajian eksperimen, sementara yang lainnya terdiri daripada ulasan, kajian kes, dan kajian keratin rentas. Kesimpulannya, kawalan postur mempunyai pengaruh yang besar terhadap kefungsian anggota atas. Kepentingan kedua-dua factor tersebut perlu ditekankan kepada ibu bapa atau penjaga kanak-kanak palsi serebral kerana pemahaman dan kesedaran di kalangan masyarakat masih belum mencukupi. Oleh yang demikian, kajian terhadap kesedaran pengaruh kawalan postur terhadap kefungsian anggota atas di kalangan penjaga adalah sangat diperlukan, begitu juga kajian mengenai pelaksanaan strategi pengurusan dalam latar masyarakat.

Kata kunci: Kanak-kanak palsi serebral; kawalan postur; pengubahsuaian postur; kefungsian anggota atas; mencapai

INTRODUCTION

Cerebral palsy or CP is a non-progressive defect or lesion in the immature brain that will cause disorders of motor and postures (Chung et al. 2008; Huang et al. 2008), including postural control (Bigongiari et al. 2011; Cheng et al. 2013; Ju et al. 2010), that limits childrens' participation in daily living activities (Cheng et al. 2013; Huang et al. 2008). Deficiency of postural control are the cause of deficits in motor behaviour (Brogren et al. 2001; van der Heide et al.

2004; Zadnikar & Kastrin 2011) and developmental delays in CWCP (Donker et al. 2008).

Postural control can be defined as “a mechanism of sensorimotor strategies for the regulation of posture stability” (Chung et al. 2008; Grant 1999; Hadders-Algra 2013; Shumway-Cook & Woollacott 2012). It develops differently between CWCP and typical developing (TD) children (Bigongiari et al. 2011). Besides affecting sitting position, postural control can have influence in planning movement accordingly (Chung et al. 2008).

Postural control is correlated with hand reaching performance. Adequate postural control interacts with upper extremity control to ensure successful movement of hand to the target without loss of balance (Ju et al. 2010). However, literature reviews highlighting tahe relationship between postural control and upper extremity function among CWCP have not yet been produced. Only a few studies have addressed the postural control relation and influence on upper extremity function. Awareness among caregivers on the importance of good postural control contribution in enhancing upper extremity function needs to be emphasised. Hence, the purpose of this paper is to review previous literature upon the relationship between postural control and upper extremity function in CWCP.

METHODOLOGY

SEARCH PROCEDURES

Literature searches were conducted in various electronic databases: ProQuest; Science Direct; Springer Link; Sage; Wiley Online Library; and Google Scholar using specific key terms ‘children with cerebral palsy’ AND ‘postural control’ OR ‘postural adjustments’ AND ‘upper extremity function’ OR ‘reaching’ AND ‘sitting’ and from references of retrieved articles. Only articles in English from 2000 to May of 2015 were searched. They were examined for (1) Methods of the study; (2) Purpose of study; and (3) Key findings and results of analysis.

The search yielded 95,601 articles. Forty three articles were selected based on titles and abstract. The articles were then further excluded until 19 articles due to (1) The article retrieved is not in full text (2) the participants were not children or adolescents with cerebral palsy (3) the content is not discussing about postural control and/or its relation with upper extremity function (4) Article on validation of an assessment or model of intervention (5) Article on reliability of an assessment or model of intervention. The article selection flow may be seen in Figure 1.

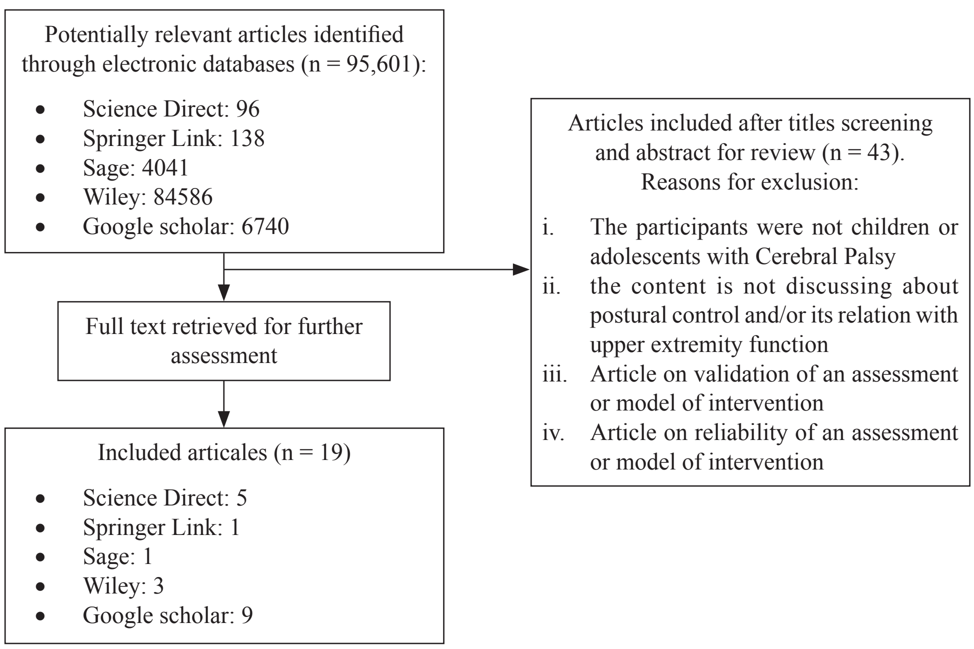

FIGURE 1. Article selection flow

RESULTS

Nineteen journal articles that were published from 2000 until 2015 were found (Table 1) for authors, methods, population, purpose, key findings and results of analysis). Of these, 11 articles are experimental studies, while others are descriptive study (1 article), systematic review (1 article), review (4 articles), cross-sectional study (1 article) and case study (1 article).

THE IMPORTANCE OF POSTURAL CONTROL IN MOTOR PERFORMANCE

Three studies address on the importance of postural control in motor performance. Bigongiari et al. (2011) highlight the importance of postural control sufficiency in attaining voluntary movement performance. Batra et al. (2011) reported that the development of postural control helps in movement, stability, and motor ability in CWCP.

TABLE 1. Reviewed studies

No	Authors	Methods	Population, *N*	Purpose	Key findings & results of analysis
1.	Batra et al. (2011)	Experimental	• Subjects: 38 children with cerebral palsy (CWCP) • Age: 2-7 years • IQ level: ≤ 50 • Dynamic postural control group: 19 • Conventional treatment: 19	To evaluate the effectiveness of intervention based on dynamics of postural control as key element over conventional approach in CWCP.	• The treatment of dynamics of postural control is more effective than conventional approach for development/ modification of postural reaction in CWCP.
2.	Bigongiari et al. (2011)	Experimental	• Control group: 12 typical developing (TD) children • Experimental group: 12 CWCP	To examine postural control in CWCP performing a bilateral shoulder flexion to grasp a ball from a sitting position.	• Result shows a positive relationship between EMG and aging for control group, however the relationship was negative for participants with CP. • The researcher suggested that the main postural control strategy in children is based on corrections after the beginning of the movement. • The linear relationship between EMG and aging suggests the postural control development is affected by central nervous disease that lead to increase in muscle co-activation.
3.	Brogren et al. (2001)	Experimental	• Control group: 10 TD children • Experimental group: 10 CWCP with mild to severe spastic diplegia • Age: 3-7 years 6 months	To explore whether the deviant postural adjustments in children with spastic diplegia is due to their crouched sitting position or totally due to their neural deficit.	• TD children exhibit a distinct postural adjustments adaptation to sitting position. • The CWCP had a deficits adaptational capacity that is more visible in the erect than in the crouched position. Hence the crouched sitting position did not cause postural deficiency but offer a solution to sensory-motor problem of the instability experienced. • Children with severe diplegia show lack of direction specificity in the leg muscles during backward body sway that points to a basic deficit in postural control. The children exhibit dysfunctions in the precise tuning of the postural adjustments to task-specific conditions.
4.	Carlberg & Hadders-Algra (2005)	Description	N/A	• Description of pathophysiological of postural control during sitting. • The outline of implications for management and intervention of CWCP.	N/A
5.	Cheng et al. (2013)	Experimental	• Subjects: 14 CWCP (divided into 2 groups) • Age: 7-17 years old	To explore the influence of lower limb stabilization and pencil design on body biomechanics in CWCP.	• The lower limb stabilization significantly decreased the trunk lateral and forward deviations, and the visual focus-vertical angle. • The biaxial pencil and the assigned grip height design significantly decreased the head, shoulder, trunk and pelvic deviations compared with the regular design. • The results show that lower limb positioning was effective in improving the trunk posture. • A pencil with assigned grip height or with biaxial design could improve head, shoulder, trunk and pelvic alignment, however it didn't influence the muscle exertion of the upper extremity.
6.	Chung et al. (2008)	Systematic review: Electronic database/hand searches	N/A	• To review research on the effect of adaptive seating on sitting posture/ postural control in CWCP. • To examine whether changes in postural control related to changes in other aspects of functioning.	• Conflicting results were reported for saddle seats and optimal seat/ back angle for improving sitting posture/postural control. • Significant improvements were reported with inserts, external supports, and modular seating systems. However, evidence supporting effects of postural control on functional abilities was limited.

Continued

TABLE 1. *Continue*

No	Authors	Methods	Population, *N*	Purpose	Key findings & results of analysis
7.	De Graaf-Peters et al. (2007)	Review	N/A	• First part: Review of the development of postural control in TD children and in CWCP. • Second part: Review current knowledge on the effect of intervention on muscle coordination during postural development in children with typical and atypical motor development.	• The result shows that at an early post-natal age an infant possesses skill of direction-specific adjustments. The usage of the skill is depend on the child's age and the nature of the postural task. • CWCP have the ability to generate direction-specific adjustments, but they have a delayed development in the capacity to recruit direction-specific adjustments in tasks. CWCP have difficulties in fine-tuning of postural activity. • Intervention using balance training with active trial and error experience may improve postural control in children with or at high risk of developmental motor disorder.
8.	Donker et al. (2008)	Experimental	• Subjects: a. TD children: 9 b. CWCP: 10	To examine the structure of Centre of Pressure (COP) trajectories in CWCP and TD children.	• CWCP have larger and regular amount of sway. • CWCP might gain benefit from therapies involving postural tasks with external functional context for postural control.
9.	Hadders-Algra (2013)	Review	N/A	To review the development of reaching and its associated postural control during infancy, in particular in supine and sitting positions during the first postnatal period.	• Atypically developing infants have difficulties in adapting postural adjustments and may have reduction of repertoire. • Most reaching movements are performed during sitting in infancy. • The postural challenge of sitting may interfere with the development of reaching in atypically developing infants.
10.	Harbourne et al. (2010)	Experimental	• Subjects: a. TD children: 15 b. CWCP: 35 infants that have delayed development & at risk for CP (they were divided into 2 intervention groups; home program & perceptual motor program)	To compare two interventions for improving sitting postural control in infants with CP.	• Although both TD children and CWCP made progress in Gross Motor Function Measure (GMFM), the group with perceptual-motor intervention show advantage on the COP (centre-of-pressure) measures. The COP measures appear sensitive for assessment of infant postural control and quantifying intervention response.
11.	Harbourne & Kamm (2015)	Case study	• 3 case examples of: 1. An infant with cerebral palsy learning to sit and reach 2. A school-aged child with developmental coordination problems 3. An adolescent with congenital acquired hemiplegia	To explore the relationship of posture and reaching and assumptions from the historic neuro-maturational therapeutic approaches.	• Posture and arm function is completely linked according to previous research findings. • To learn new upper extremity skill treatments, it is essential to have: 1. Variability and problem solving; 2. Linkages between posture and upper extremity use with each challenge; 3. Linking in time the movement planning of posture and upper extremity; 4. Consideration of developmental time in attaining a skill; 5. Work across and within various postures; and 6. Use of errors to build new strategies • The principles, examples, and clinical suggestions described by the authors provide challenges to current care as well as a platform for further research and improvement of intervention for those with neuromotor impairments.

Continued

TABLE 1. *Continue*

No	Authors	Methods	Population, *N*	Purpose	Key findings & results of analysis
12.	Ju et al. (2010)	Experimental	• Subjects: a. TD children: 16 b. CWCP: 8	To examine: 1. The effect of task constraint on the reaching with spastic CP. 2. The correlations be-tween reaching performance and postural control.	• Compared to TD children, CWCP exhibit slower, skewed, less efficient and less coordinated pattern of reaching. CWCP have impaired reaching performance when reaching laterally and medially (more skewed and less efficient). • Reaching laterally & medially: involve trunk rotation that produces more postural challenges compared to reaching anteriorly. • Finding of this study highlight the difference in the effect of task constraint on hand reaching performance between TD and CWCP groups. • The straighter and more efficient and coordinated reaching performance can be achieved with better postural control capabilities.
13.	Ju et al. (2012)	Cross sectional study	• Subjects: a. CWCP: 12 b. TD children: 16	• To examine the effect of reaching in different directions on postural adjustments in diplegic CP. • To examine the relationship between hand reach performance and postural adjustment. • To examine the relationship between postural control ability and postural adjustment.	• Compared to TD children, CWCP exhibit more crooked and less efficient COP patterns, specifically on medial or lateral reaches. • More postural challenges usually during reaching medially or laterally involve trunk rotation, compared to reaching anteriorly. • The postural adjustments patterns in CWCP were related with their postural control ability and hand-reach smoothness.
14.	Ledebt & Savelsbergh (2014)	Experimental	• Subjects: a. CWCP: 6 (congenital hemiplegia) b. TD children: 6 • Age: 5-11 years old	• To analyse the postural adaptation during unilateral and bilateral rapid arm movement and to relate these postural shifts to the size of the base of support (BOS) and to the limits of support (LOS).	• Compared to TD children, children with unilateral Cerebral Palsy limits of stability (LOS) forward and toward non-dominant (more affected) side were smaller than in the TD children. • LOS backward and toward the dominant (less affected) side did not differ between the two groups.
15.	Pavão et al. (2014)	Experimental	• Subjects: a. CWCP: 10 (spastic hemiplegia spastic diplegia) b. TD children: 27 • Age: 5-12 years old	• To examine functional performance and balance in CWCP and TD children. • The relationship between these components and postural control during sit-to-stand (STS) movement.	• Participant shows deficits in their level of functional performance and balance compared to TD children although the participants had mild to moderate motor impairment. • In both groups, impairments in postural control during STS movement are correlated to functional performance. • The result marks the importance of the structure and function components to the children's activity level.
16.	Stavness (2006)	Reviews	N/A	To review evidence on the most appropriate seating position for CWCP in promoting energy con-servation and maximize upper extremity function.	CWCP should be fitted for wheelchairs that place them in functional sitting position (FSP) to enhance upper extremity function, which includes: a. Orientation in space (0°-15°) b. Hip belt c. Abduction Orthosis (AO) d. Footrests e. Cut-out tray f. Sloped-forward seat of 0°-15° g. The exact seat angle and orientation in space within 0°-15° range should be determined on individual basis

Continued

TABLE 1. *Continue*

No	Authors	Methods	Population, *N*	Purpose	Key findings & results of analysis
17.	Van der Heide et al. (2004)	Experimental	• Subjects: 58 CWCP (preterm children) 1. 34 with spastic hemiplegia 2. 24 with bilateral spastic CP • Age: 2-11 years old	To assess the postural control during reaching with the dominant arm in preterm CWCP.	• Most CWCP have intact a basic level of postural control (direction specificity). However they exhibit dysfunction in: a. Recruitment order of postural muscles (exhibit stereotyped top-down recruitment). b. Ability to modulate muscle contraction to task specific conditions. It may be seen more in children with bilateral CP than those with Spastic hemiplegia. • Degrees of disability in daily living activities have relation with postural dysfunction.
18.	Van der Heide & Hadders-Algra (2005)	Review	N/A	To overview the knowledge available on muscular discoordination underlying postural problems in CWCP.	• Problem in adaptation of degree of muscle contraction might be the cause CWCP show excess of antagonistic co-activation during difficult balance tasks and a preference for cranial-caudal recruitment when reaching compared to TD children. These might be considered as functional strategies to compensate for the dysfunctional capacity to modulate postural activity.
19.	Van der Heide et al. (2005)	Experimental	• Subjects: a. CWCP: 1. Spastic hemiplegia (SH): 33 2. Bilateral CP (Bi-CP): 18 b. TD children: 26 • Age: 2-11 years	To investigate the relation between CWCP postural control kinematics and quality of reaching kinematics.	• Sitting posture: CWCP have different postures before reaching onset compared to TD children. CWCP sat with more reclined pelvis that has relation with better quality of reaching motions and more collapsed trunk. • The pelvis and trunk different sitting postures were not associated to activities of daily living functional performance. • CWCP with more stable head, trunk and pelvis were correlated to better functional performance and/or better quality of reaching.

Inadequate force production (Bigongiari et al. 2011) and individual demands and environmental context (Ju et al. 2010) to maintain postural control may lead to abnormal posture (Batra et al. 2011; Chung et al. 2008), cause functional difficulties in eye-hand coordination (Batra et al. 2011; Kyvelidou 2011; McDonald et al. 2004), as well as motor development deficits (Batra et al. 2011; Brogren et al. 2001).

FACTORS THAT AFFECT POSTURAL CONTROL

There are a few factors that can affect postural control stability. Motor disorders, sensory, velocity of body sway, base of support (BOS), and attention can affect postural control. These factors are highlighted by five studies (Bigongiari et al. 2011; Carlberg & Hadders-Algra 2005; Donker et al. 2008; Kyvelidou 2011; Reilly 2005). Motor disorders condition in CWCP can lead to postural control limitations (Bigongiari et al. 2011; de Graaf-Peters et al. 2007). During functional task, CWCP usually perform with lower muscle activity (Bigongiari et al. 2011), which may cause instability of posture to conduct activities of daily living.

Besides that, changing sensory environment also contributes to the postural stability (Reilly 2005) and CWCP have deficits of the sensory system (Saavedra et al. 2010). Compared to the TD children, the spastic and ataxia types of CP rely totally on somatosensory information for postural control (Brogren et al. 2001; Reilly 2005) and experience instability when only vestibular information is available (Reilly 2005; Saavedra et al. 2010). The second level of adaptation of the direction-specific adjustments is based on the multisensory afferent input from somatosensory, visual, and vestibular systems (Hadders-Algra 2013).

Body sway level and velocity too play a role in postural stability. The stability of posture is lessened when body sway is greater and faster (Reilly 2005). The CWCP have smaller total sway path and range of Medio lateral sway compared to TD children. This causes a rigid posture with limited variation in frontal plane (Hadders-Algra 2013).

Base of support (BOS) is one of the factors that constraints the postural control. Many CWCP chose to accomplish daily living activities in sitting because more stability (higher BOS) may be gained in this position (Brogren et al. 2001; Carlberg & Hadders-Algra 2005).

Apart from this, Donker et al. (2008) stated that attention plays a major role in postural stability. An external focus of attention can enhance motor skills while internal focus can cause disruption to perform activities. This is because during external focus of attention, attention is 'diverted' from one owns body towards the task. Postural visual feedback can aid an increase in external focus of attention.

POSTURAL ADJUSTMENTS

Postural controls have two functional levels. The first level is generation of direction-specific adjustments whereby the dorsal muscles are activated when the body sways forward, while ventral muscles will be activated when the body sways backward (Hadders-Algra 2005; Hadders-Algra 2013). The next level is an adaptation of the direction-specific adjustments in which infants (age 6 months onwards) are capable of adapting postural activity to certain situations (de Graaf-Peters et al. 2007; Hadders-Algra 2005).

Direction-specific postural adjustments usually occur after successful grasping of infants at age 4 to 5 months (Bigongiari et al. 2011; Hadders-Algra 2005). As the infants learn to use postural adjustments they can achieve the task targets much better by time due to aging (Bigongiari et al. 2011). Hence, through different demands of hand reaching, the postural adjustments can be changed (Ju et al. 2012).

CWCP have the capabilities to generate direction-specific adjustments (Brogren et al. 2001; de Graaf-Peters et al. 2007), however they display delay development to train direction-specific in activities (de Graaf-Peters et al. 2007). Postural adjustment of CWCP shows a correlation with the combination of postural control capabilities and hand reaching performance (Ju et al. 2012). However, they suffer from a severely restricted repertoire of adjustments (Hadders-Algra 2013).

Severe CWCP with Gross Motor Function Classification System (GMFCS) Level V will display total deficits in direction-specific postural adjustments and are 'non-sitting' children (Brogren et al. 2001; Carlberg & Hadders-Algra 2005; de Graaf-Peters et al. 2007). CWCP with GMFCS Level IV at hip level and Level III of young children will experience partial loss of direction-specific (Brogren et al. 2001; Carlberg & Hadders-Algra 2005). This statement is also supported by Brogren et al. (2001) in that musculoskeletal constraints contribute to postural adjustment in children with spastic diplegia.

POSTURAL CONTROL WHILST SITTING

Two studies (Ju et al. 2012; Kyvelidou 2011)stated that infants will achieve sitting independently by the age of 6 to 9 months. In order to have a stable sitting with enhance upper extremity function, infants need adequate control of trunk and pelvis, stable base of support (BOS) of lower extremity (Grant 1999; Ju et al. 2012; Kyvelidou 2011) and sufficient information from vestibular, somatosensory and visual systems inputs (Kyvelidou 2011).

Postural control has an important influence on sitting (Costigan, & Light 2010; Rodby-bousquet & Hägglund 2010) as described in three previous studies (Harbourne et al. 2010; Kyvelidou 2011; McDonald et al. 2004). Firstly, it promotes a functional sitting posture (McDonald et al. 2004) to accomplish functional tasks (Grant 1999; Harbourne et al. 2010; Ju et al. 2012; Kyvelidou 2011).

Furthermore, increase success of reaching in sitting position is closely related to the existence of direction specificity and good postural control (Hadders-Algra 2013).

The earliest upright posture is sitting postural control (Harbourne et al. 2010). Previous studies described how sitting in an upright position encourages respiration (Redstone 2004) and allows infants or children to improve perception, social and cognitive development (Harbourne et al. 2010; Kyvelidou 2011). However, CWCP usually have limitations to maintain balance in an upright position as having higher centre of mass and small BOS of their posture. Therefore, they may end up spending a lot of time in a sitting position(Ju et al. 2010, 2012).

The crouched sitting position is not due to a lack of postural adjustment and does not encourage postural deficits; instead, it provides a solution to sensory-motor limitations. However, such a posture can cause problems and limits the usage of upper extremity for functional tasks for CWCP (Brogren et al. 2001).

HEAD STABILITY

Good sitting and standing positions require a stabilized head and trunk together with alignment (Bigongiari et al. 2011). The onset of reaching occurs after head and upper extremity control (Ju et al. 2010). In order to achieve a stabilized head, good postural control is needed (Saavedra et al. 2010).

Head stabilization in space is an important objective of postural control (de Graaf-Peters et al. 2007) and a better stability of the head in space have correlation with complete pattern of direction specific postural adjustments (Hadders-Algra 2013). The skill of a stabilized head may be achieved through practice of new experience involving balance problem (Saavedra et al. 2010) and from trial and error (Hadders-Algra 2005). CWCP head instability while performing dynamic tasks is due to trunk muscle activation in abnormal patterns (Saavedra et al. 2010).

POSTURAL CONTROL & UPPER EXTREMITY FUNCTION: THE RELATIONSHIP

Three studies found that, postural control has crucial effects on upper extremity function, specifically on the dexterity and motor control (Chung et al. 2008; Costigan & Light 2010; Grant 1999). In order to engage in the performance of activities of daily living, upper limb function is considered as one of the important factors (Chung et al. 2008).

In addition, it has been found that postural control ability can influence reaching performance (Hadders-Algra 2013; Harbourne & Kamm 2015; Ju et al. 2012). Reaching is a task engaging extensive neural circuitries; whereby primary motor and somatosensory cortices, frontal and parietal areas play significant parts (Hadders-Algra 2013) and can be influenced by external environment such as adaptive seating (Ju et al. 2012). The arm, hand, and trunk are programmed together in a fixed temporal order during the reaching movement to assist transporting the hand to the target in a precise way. Such a program strategy may be useful in movement coordination, but requires stable control of the trunk through a longer movement path (Carlberg & Hadders-Algra 2005).

Evidence has shown that CWCP requires extra/further trunk movement when they try to reach forward (Ju et al. 2012) and suffer from insufficient control of reaching due to less force production, coordinated movement limitations, and reduced efficiency of hand transportation towards targets (Ju et al. 2010). The CWCP will demonstrate trunk rotation, trunk side bending, and extra/further trunk forward movement to compensate for their impaired hand control during functional task (Ju et al. 2012).

Besides that, CWCP with impaired postural control have difficulty with reaching in sitting compared to a supine position (Hadders-Algra 2013).Task constraints on reaching performance (reaching speed and direction) can affect CWCP's control strategies while performing task. Compared to TD children, CWCP demonstrated less straight reaching direction laterally and medially as they were affected by task constraint. Although CWCP show different control strategies to certain degree, they have the ability to modulate their extremities and body to accomplish activity needs successfully (Ju et al. 2010).

Poor sitting posture can disturb CWCP learning process. These children show abnormal movement and postures that may affect their handwriting. The sacrum-sitting position does not promote writing with upper extremities. It is because in this position, children need to pay a lot of attention and energy to the task of sitting and controlling upper limb movements, diverting them from handwriting activities. Hence, proper positioning is important for the upper extremities to function successfully (Cheng et al. 2013).

Poorly organized postural responses, increased muscle co-activation at individual joints and movement limitation are the effects of stronger single and agonist/antagonist muscle activations in CWCP. Strong single muscle responses are caused by lack of supra spinal modulation on tonic stretch reflex thresholds at segmental levels, spasticity, or an immature central nervous system (CNS). The delays in the development of specific neural or musculoskeletal subsystem and sensorial deficits may be a factor of balance difficulties (Bigongiari et al. 2011).

THE SOLUTION TO THESE PROBLEMS: MANAGEMENT STRATEGIES

According to Pountney& Green (2004), management strategies are continuous strategies that support a treatment. These strategies should be conducted within the child's daily functioning and not occur as solitary daily activity (Pountney & Green 2004). Postural management programs, functional activity training, and home programs are parts of a management strategy.

POSTURAL MANAGEMENT PROGRAM

A postural management program for CWCP may be defined as a planned approach comprising all activities and interventions which impact on an individual's posture and function (Gough 2009). It is an essential program that assists CWCP who cannot sit independently, cannot change position, or require more support to maintain postural stability when performing a functional task. Without adequate support, a CWCP may not be able to engage in activities and may maintain postures which could lead to deformity (Pountney & Green 2004).

For CWCP who have limited postural control and poor sitting balance, proper seating and positioning is a crucial management goal (Nwaobi 1987). With the approach of positioning CWCP in a correct posture and avoiding abnormal movement, a stereotypical pattern needs to be supported by postural management equipment. Parents also need to be taught and supported to position their child appropriately (Pountney & Green 2004). Adaptive seating (Grant 1999; McDonald et al. 2004; Rahman et al. 2012) and seat surface inclination (Arakaki et al. 2012) are the example of support for CWCP proper positioning.

FUNCTIONAL ACTIVITY TRAINING

Continuous functional activity training and neuromuscular rehabilitation are compulsory to deal with CWCP postural and movement limitations. Moreover, during rehabilitation programs, multisensory stimulation activities should be applied to increase postural and motor control (Bigongiari et al. 2011). An efficient movement patterns can be formed through trial and error (Carlberg & Hadders-Algra 2005). Previous findings have shown that 20 minutes of daily movement training for two to four months facilitates reaching ability and object manipulation in preterm infants (Hadders-Algra 2013).

HOME PROGRAM

Arakaki et al. (2012) stated that patients who joined occupational therapy home program could depend on the support of their parents as part of the rehabilitation process. This program has been proven to succeed and it has been suggested that the program for upper extremity take a minimum of eight weeks, 17.5 times a month, in sessions of an average duration of 16.5 minutes (Arakaki et al. 2012).

Guidance on enhancing reaching performance including practice of balance control during daily activities should be taught to parents. Besides that, parents and caregivers are encouraged to provide situations that allow the infant experiencing the joy of reaching and grasping toys. CWCP's families need to be informed about various methods with which infant development can be encouraged (Hadders-Algra 2013).

DISCUSSION

During the review, the paper focused on the information regarding the postural control affect towards upper extremity performance and its management. Review of the current literature concludes that there is less evidence concerning the relationships between visual, somatosensory, and vestibular systems with posture, especially during sitting.

Furthermore, there is also less evidence concerning the vision effect towards head stability during sitting position in CWCP. Head stability plays an important role in enhancing upper extremity performance. Besides that, the studies on the effects of attention on task towards postural control also show less evidence in this topic.

The papers that have been included in this study are mostly of an experimental type, while others were based on reviews and case studies, with one cross-sectional study. Most of the papers have small number of sample size and the generalization of the findings is limited.

Most of the papers have described the development of postural control and its relation with upper extremity function. One of the findings (Harbourne & Kamm 2015) showed that infants' reaching repertoire actually starts earlier than the accomplishment of postural control. However, there are still limited findings on the relationship between postural control and seated reaching task and ability among CWCP (Ju et al. 2010).

Despite a lack of evidence on the relation between postural control and upper extremity, previous reports in the literature regarding the usage of supportive seating to improve the upper extremity function in appropriate angle or condition are well covered. This provide crucial information for occupational therapists to consult on the prescription of adaptive seating supporting upper extremity function in clients (Grant 1999).

The issues regarding postural adjustment role in postural control ability are also well discussed in the previous literature. Most journals have highlighted the role of the postural adjustment as the basic repertoire that is required to attain stability. The papers also provide information about the development of postural control that includes its component, phase and analysis.

Moreover, through these reviews, the performance of upper extremity ability, for example reaching either during sitting or standing in TD children or CWCP, can be compared. These findings are important as it provides knowledge to therapist on which best position to place the toys or object in a child's hand or infant's hand. This is needed to encourage combinations of lateral and bilateral hand movements (Grant 1999).

The postural management strategies also plays crucial role in assisting and maximizing the CWCP's activity of daily living. Various strategies should enhance the children's abilities and at the same time improve their quality of life.

CONCLUSION

In summary, postural control has an influence on upper extremity function. This study is important to create awareness on the part of occupational therapists for parents or caregivers of CWCP as this matter may remain disregarded or unknown to them. After awareness is achieved, then the management strategies can be implemented within the community. Postural control and upper extremity function relation knowledge is essential as the core application of the management strategies. These strategies may support upper limb abilities of CWCP to complete the functional activities. From these various approaches, the CWCP upper extremity function performance can be increased, at the same time enhancing activities of daily living and subsequently improving the quality of life. Therefore, a study on the awareness of the postural control influence on upper extremity function among caregivers and the implementation of management strategies in community settings is vitally needed.

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