INTRODUCTION

Population of adults with cerebral palsy

Cerebral palsy (CP) is the most common motor disability in children with an estimated prevalence of 2.6 to 2.9 per 1,000 births in the United States between 2011 to 2013 [1]. According to a study conducted in South Korea, the prevalence of CP was 3.2 per 1,000 children in 2008 [2]. Improvements in the level of medical care have resulted in a steady decline in the incidence and severity of CP in prematurely born children since 1990 [3]. However, the population of adults with CP is increasing along with the increased survival rate of infants born with the disability [4]. A survey of individuals with CP born after 1990 revealed that 60% of the children at Gross Motor Functional Classification System (GMFCS) level V and 96% of the children at GMFCS level I or II survived until 19 years of age [5]. According to data based on the surveillance rates
in Sweden up to 50 years of age [6], the risk of death in all age groups was consistently high in adults with CP. In a long-term study of patients with CP between 1959 and 2002, it was reported that 180 of 1,880 (9.6%) individuals died during the follow-up period. Individuals with mild-to-moderate motor impairment had a cumulative survival rate of more than 95% at age 50, compared with 74.5% among those with severe motor impairment. It was estimated that approximately 400,000 adults with cerebral palsy lived in the United States in 1995, which is gradually increasing due to medical advances and prolonged life expectancy, with an estimated number of more than 1,000,000 adults with CP in the US currently [7].

TRANSITION TO ADULTHOOD

CP is superimposed on the dynamic process of development and aging despite being defined as static motor impairment [8]. Adults with CP need health services for the continued monitoring and management of their condition. Furthermore, the development of additional health problems in adulthood increases the need for ongoing access to health services.

Health challenges diagnosed in adults with CP differ from those in childhood and adolescence in patients with CP. Individuals with CP manifest an increased risk of death due to cancer including breast cancer and cancers of digestive and genitourinary organs [9]. In addition to ongoing needs traced to childhood, regular reviews of cardiovascular health, cervical cytology and mammography in women, access to dental care and screening is important in adults diagnosed with CP. Adults with CP have been additional diagnosed with chronic pain and fatigue, osteoarthritis and osteoporosis, and an overall reduction in mobility [10]. According to Young et al. [11], adults with complex physically disabling conditions acquired in childhood including CP exhibit ongoing health issues and require frequent medical care. Their hospitalization rate was 9-fold higher than that of adults without disability. The pediatric and adult healthcare systems are structurally distinct in most countries, and the transition to adult healthcare occurs at 18 or 19 years old [12]. This transition is determined by age alone and not based on the patient’s ability to direct their own care. Therefore, at a point when most adults are not ready to inherit further responsibility for their own medical care, they are switched to a more independent adult-oriented healthcare system.

It is also reported that young people diagnosed with CP do not receive sufficient information prior to transitioning underscoring the need to foster knowledge and improve their skills during the transition period [13]. To overcome these apparent challenges, we need to fully understand the healthcare needs of adults with CP in order to guide the development of adult-focused health services [14]. The transition from childhood to adulthood in CP has been debated for the past 20 years with aging now emerging as a new and independent challenge. Also, the current knowledge of physiatrists among elderly adults with CP is an important issue.

GENERAL HEALTH ISSUES

Cardiometabolic and pulmonary morbidity

In a population-representative sample in United States, adults with CP were found to carry a higher rate of chronic conditions [15] such as diabetes, asthma, hypertension, other heart conditions, stroke, and emphysema than adults without CP. In middle-aged adults with CP between the ages of 40 and 60 years [16] and young adults with CP [17], the proportion of individuals with multiple morbidity (≥2 among 12 chronic conditions) was high. Furthermore, obesity and a high GMFCS level were linked to increased risk of multimorbidity.

Risk factors for cardiovascular disease exist among young adults diagnosed with CP [18-20]. Age has been identified as the strongest independent predictor of vascular health [19,20], with a higher prevalence of non-ambulatory than ambulatory CP [21]. Also, fatigue [22,23] and bowel symptoms [24] were prevalent in adults with CP. According to Ryan et al. [25] in Ireland, the prevalence of metabolic syndrome was high in 55 young adults with CP with an average age of 37.5, with a prevalence of 20.5% among ambulatory adults and 28.6% in non-ambulatory adults. In a study of young adults with ambulatory CP, moderate physical activity was reported to be associated with a lower cardiometabolic risk suggesting that fitness and physical activity were important measures to reduce non-communicable disease [25-28].

Unmet healthcare needs

Rehabilitation facilities were insufficient to manage ag-
ing in adults diagnosed with CP in spite of reduced func-
tional abilities [29]. Surveys conducted in Sweden during
the year 2001 suggested that 60% of the cohorts inves-
tigated were engaged in some kind of physical training
[30]. As reported by Balandin and Morgan [31] in 1997,
20% of adults with CP have difficulties accessing medical
services and 41% lack access to facilities. Furthermore,
the survey also highlighted difficulties in communica-
tion and the need for external assistance. According to
a recent report in South Korea [32], the medical check-
up rate including private health screening, workplace
health checks, medical check-ups provided by national
health insurance services, and free medical check-ups
in adults with CP were lower than in the total population
with disabilities, with financial burden cited as the big-
gest factor preventing hospital attendance. According to
the study, 53.2% of the individuals underwent a medical
check-up in the past 2 years, while 44.2% did not [32].
Only one-third (37.0%) of individuals with CP received
rehabilitation therapy in South Korea [32]. Individu-
als with CP reported the need for the following medical
treatments: pain treatment (42.9%), additional physical
therapy (35.7%), examination by a physiatrist (27.3%), or-
thosis prescriptions (14.3%), occupational therapy (11%),
and surgery (3.9%) [32]. In addition, due to the financial
burden and lack of knowledge of patients diagnosed with
CP, the demand for rehabilitation services was not met in
one-third of all adults with CP.

DETERIORATION IN PHYSICAL ACTIVITY

In adults with CP, physical activity was reported to de-
crease with increasing GMFCS levels [33]. There is a lack
of evidence supporting the efficacy of the intervention
to sustain and increase habitual physical activities in
children and youth with CP [34-36]. The effect of dete-
rioration in physical activity or exercise intervention on
long-term health in patients with CP has yet to be elu-
cidated. In line with the previous review, the Cochrane
study group revealed that there is low-to-very low-quality
evidence supporting the benefit of physical activity in
children in terms of improved gross motor function and
gait speed [35]. Although few studies have examined the
effects of physical activity in adulthood, increased physi-
cal fitness in young adults with spastic CP was effective
in improving fatigue, mental health, and social participa-
tion without a significant change in gross motor func-
tion [23]. Although physical activity is expected to have
a significant long-term impact on adults compared with
pediatric populations, studies have yet to investigate the
effects of physical activity in adults. A comprehensive re-
view and further analysis of the effects of physical activity
on adults with CP are needed.

MUSCULOSKELETAL ISSUES

Osteoporosis and arthritis

Adults with CP may be at an increased risk of hypovita-
mnosis D-induced osteopenia and impaired bone mass
[37]. Adults with CP are more frequently deficient in vita-
min D due to the use of anticonvulsants or fewer outdoor
activities. Recent studies have shown an insufficient or
deficient vitamin D levels in more than 50% of the adults
with CP based on abdominal obesity, which is an inde-
pendent predictor of lowered vitamin D levels [38]. Lim-
ited weight-bearing, inappropriate nutrition, medica-
tions (especially for the treatment of epilepsy), and other
factors represent potential risk factors for the early onset
of osteoporosis [10].

According to a study regarding the age-related trajec-
tory in adults with CP, the odds ratios of osteoporosis,
osteoarthritis, and rheumatoid arthritis in adults aged
30 years and older were higher than in those aged 18–30
years [39]. Multiple musculoskeletal morbidities among
adults aged 31 to 40 years were 1.9-fold higher compared
with adults aged 18–30 years, 4.3-fold in adults aged 41 to
50 years, and 6.1-fold higher than those above 50 years.
Low bone mineral density was also observed in ambula-
tory adults with CP [40,41], along with frequent fragility
fractures [42]. Because adults with CP are more vulner-
able to osteoporosis, more frequent check-ups and ac-
tive interventions are required starting at a younger age.
Evaluation of body composition using dual-energy X-
ray absorptiometry (DXA) or lean tissue mass is clinically
important for optimal outcomes following feeding and
exercise interventions [42]. In addition, interventions to
increase weight-bearing or muscle mass are preferred
[42]. It is also particularly important to reduce the risk
of falls in ambulatory individuals with CP [42]. Since a
greater risk has been reported in adults with CP, the de-
velopment of a protocol for the diagnosis and treatment
of osteoporosis in individuals with CP is needed.
Sarcopenia

Botulinum toxin injections, orthopedic surgery, and neurosurgical interventions are occasionally performed in children and adolescents with CP due to muscle imbalance during their developmental period. Increasing muscle mass can be a challenge due to the lack of muscle mass when children become adults.

Adults with CP carry smaller and less dense psoas major [41], suggesting greater muscle fat infiltration, poor muscle quality, and less contractile tissue in the muscles [37]. Even ambulatory young adults with CP presented with a calf area 45% smaller than in a typically developing population [43].

Because individuals with CP show a low basal metabolic rate, obesity may occur even with a calorie-controlled diet [41]. Since premature aging associated with sarcopenia in CP may cause acute functional deficits and disabilities [44] and sarcopenia is frequently detected in adults with CP, dietary modification, nutritional supplements and exercise therapy are needed. The development of a detailed exercise protocol for adults with CP is required because increased muscle mass improves strength, functionality, endurance, and general metabolic health in individuals with CP [37]. Protein intervention stimulates skeletal muscle protein synthesis and inhibits protein breakdown resulting in positive protein balance and a net gain in muscle mass [37]. Frequent exercise with protein ingestion accelerates muscle synthesis, accretion of muscle protein, and facilitates muscle hypertrophy [37]. Regular exercise is important to improve the muscle changes associated with aging in individuals with CP [37]. Supplementation with at least 800 IU of vitamin D is effective in improving muscle strength and preventing falls and fractures, and therefore, vitamin D supplementation is also important in this population [37]. A well-designed research protocol highlighting the intervention in sarcopenia treatment is also needed.

Pain

According to Murphy et al. [7], adults with CP aged below 50 years frequently reported cervical pain, back pain, muscle pain, joint pain, hand paresthesia, and overuse syndrome. A study demonstrating a 10-year long-term deterioration of perceived health and functioning found that pain and fatigue were the most common health challenges faced by adults with CP [45]. Another study revealed chronic pain (lasting more than 3 months) in 75% of the adults diagnosed with CP [22]. Multiple studies revealed that the back, hip, and the lower limbs were the most common pain locations in adults with CP [10,11,22,32,45-50]. Adults with CP also manifested pain associated with contractures, orthopedic deformities, fractures, pressure from sitting on bony prominences, as well as spasticity [44]. Despite widespread recognition of pain in adults with CP, the impact of pain-related quality of life (QOL) has not been studied adequately.

However, a large number of adults with CP cannot access medical services in South Korea [32] and as a result, are not adequately treated for pain. Adults with CP need access to medical facilities for appropriate evaluation and treatment because chronic pain may result in decreased gait function [46] and reduced QOL.

Neurological challenges associated with myelopathy

Cervical myelopathy is often induced by early degeneration of the cervical spine due to abnormal movements in adults with CP especially in adults with dyskinetic CP [51-54]. Surgical intervention has also been used to reduce exacerbation of weakness and paresthesia [55,56]. The surgical outcome was not as favorable as expected most likely due to continued and persistent neck movements after surgery.

Therefore, in order to improve the surgical outcome and to prevent the recurrence of myelopathy, dyskinetic movements should be reduced following perioperative botulinum toxin injections [52], used to reduce cervical dystonia-related pain and disability in adults with dyskinetic CP [57].

NUTRITIONAL CHALLENGES AND DYSPHAGIA

Malnutrition has been reported in adults with severe functional disability [58]. Due to the geographic dependence and altered economic status, obesity accounts for a large proportion of the nutritional challenges reported recently [17,38]. However, further studies are needed because of the paucity of evidence supporting the effect of interventions targeting obesity and malnutrition in adults with CP.

Children with CP are reported to manifest a higher prevalence of dysphagia. Adults with CP, despite maintaining the same dietary patterns as in childhood, may
experience gradual deterioration in their swallowing and mealtime capabilities.

A qualitative study investigating swallowing difficulty in adults with CP [59] reported gradual changes in swallowing capabilities starting as early as 30 years of age. Even in adults with dyskinetic CP exposed to unrestricted diets and not previously evaluated for swallowing function, a videofluoroscopic swallowing study revealed frequent aspiration without cough reflex [60] probably due to abnormal sensorimotor integration or chronic aspiration-induced desensitization of the laryngeal airway. Considering the impact of aspiration risk on general health, the swallowing function is a challenging issue in all CP populations.

However, quantitative studies investigating the prevalence and the effect of therapeutic intervention on swallowing function in this population have yet to be conducted despite the high frequency of swallowing problems directly affecting the QOL.

FUNCTIONAL LIMITATION

According to a study conducted in the Netherlands, 70% of young adults with CP between the ages of 18 and 22 reported challenges with activities of daily living [61] including difficulties in self-care, productivity, and leisure activities, especially involving recreation, leisure, meal preparation, and housework.

Adolescents with CP gradually exhibit a progressive decline in strength and functional reserve through adulthood [37]. Prior to the age of 35 years, the ability to walk decreases in adults with CP despite acquired ambulation during adolescence. Deterioration in GMFCS levels is most evident in the late 20s and early 30s, and dependence and perceived difficulties in activity influence adults with CP [45,46,62]. It has been reported that the ambulatory function deteriorates in adulthood [7,30,63], which is likely due to new medical age-related challenges in patients with CP based on the fact that the GMFCS level remained almost stable in individuals with CP until the age of 21 years [64]. If GMFCS I-III declined to IV-V with age, it is likely that adults with CP represent a burden for their family members and caregivers, and increasingly need assistive device use. Therefore, functional limitation should be addressed in health policy regulations for adults with CP.

Limitations in functional activity were found to be a major restricting factor for social participation in young adults with CP. Although intellectual disability rather than GMFCS level in children is known to have a significant impact on social participation [65,66], there is a lack of evidence to support this finding in adults with CP. Further, work participation is restricted in adults with CP who do not suffer from an intellectual disability [67], and further research is required to encourage increased participation in society and in the workplace.

The International Classification of Functioning, Disability and Health (ICF) guidelines were developed to accurately assess the function of individuals with disabilities. The ICF Children and Youth version (ICF-CY) core set was used to measure functional limitation in children and adolescents with CP below 18 years of age [68]. The ICF core set in adults with CP has yet to be developed and the need to use ICF to accurately assess adults with CP has been highlighted [10]. Recently, there has been a move to develop the ICF core sets for adults with CP.

HEALTH-RELATED QUALITY OF LIFE AND SOCIAL PARTICIPATION

Adults with spastic bilateral CP are reported to have difficulty engaging socially and have a low health-related quality of life (HRQOL) [69]. According to a 8-year follow-up study conducted in Canada on adults with CP, HRQOL deterioration was most evident in their late 20s and 30s [70]. However, a longitudinal multicenter study conducted in the Netherlands reported lower HRQOL in adults with CP than in populations without disability and found that HRQOL and social participation were fairly stable for many years [71].

To date, a 36-item Short Form Health Survey (SF-36) has been used to evaluate HRQOL in adults with CP [26,45,63,69,71] although they have not been validated in this population. The survey consists of physical functioning, physical role, bodily pain, general health perception, vitality, social functioning, emotional role and mental health. Each area is assigned a maximum score of 100 points. Among these items, physical functioning and physical role are reported to be low in adults with CP in the Netherlands [69]. Although the SF-36 is applicable only to people without cognitive impairment and cannot be used to evaluate individuals with intellectual dis-
abilities, it can be suggested as a useful assessment tool for adults with CP. Unmet needs for medical and rehabilitation treatment in South Korea represent a possible barrier to improved QOL and social participation among individuals with CP, and therefore, appropriate financial and technical resources are required to address the unmet needs of these populations in the healthcare system [32].

CONCLUSION

In addition to early detection and habilitation or rehabilitation of children with CP, transition to adulthood has been highlighted as an important issue in the past 10 to 20 years. Aging in this population is an emerging issue. Physiatrists require adequate knowledge to prepare for the aging population of adults with CP and further studies are needed to investigate the impact of physical activity, nutrition, sarcopenia, myeloradiculopathy, and swallowing function in these individuals.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

AUTHOR CONTRIBUTION

Conceptualization: Bang MS. Writing – original draft: Yi YG, Bang MS. Writing – review and editing: Yi YG, Jung SH, Bang MS. Approval of final manuscript: all authors.

REFERENCES

1. Maenner MJ, Blumberg SJ, Kogan MD, Christensen D, Yeargin-Allsopp M, Schieve LA. Prevalence of cerebral palsy and intellectual disability among children identified in two U.S. National Surveys, 2011-2013. Ann Epidemiol 2016;26:222-6.
2. Park MS, Kim SJ, Chung CY, Kwon DG, Choi IH, Lee KM. Prevalence and lifetime healthcare cost of cerebral palsy in South Korea. Health Policy 2011;100:234-8.
3. van Haastert IC, Groenendaal F, Uiterwaal CS, Termote JU, van der Heide-Jalving M, Eijsermans MJ, et al. Decreasing incidence and severity of cerebral palsy in prematurely born children. J Pediatr 2011;159:86-91.e1.
4. Mutch L, Alberman E, Hagberg B, Kodama K, Perat MV. Cerebral palsy epidemiology: where are we now and where are we going? Dev Med Child Neurol 1992;34:547-51.
5. Westbom L, Bergstrand L, Wagner P, Nordmark E. Survival at 19 years of age in a total population of children and young people with cerebral palsy. Dev Med Child Neurol 2011;53:808-14.
6. Himmelmann K, Sundh V. Survival with cerebral palsy over five decades in western Sweden. Dev Med Child Neurol 2015;57:762-7.
7. Murphy KP, Molnar GE, Lankasky K. Medical and functional status of adults with cerebral palsy. Dev Med Child Neurol 1995;37:1075-84.
8. Blum RW, Garell D, Hodgman CH, Jorissen TW, Okinow NA, Orr DP, et al. Transition from child-centered to adult health-care systems for adolescents with chronic conditions: a position paper of the Society for Adolescent Medicine. J Adolesc Health 1993;14:570-6.
9. Strauss D, Cable W, Shavelle R. Causes of excess mortality in cerebral palsy. Dev Med Child Neurol 1999;41:580-5.
10. Haak P, Lenski M, Hidecker MJ, Li M, Paneth N. Cerebral palsy and aging. Dev Med Child Neurol 2009;51 Suppl 4:16-23.
11. Young NL, Steele C, Fehlings D, Jutai J, Olmsted N, Williams JI. Use of health care among adults with chronic and complex physical disabilities of childhood. Disabil Rehabil 2005;27:1455-60.
12. Young NL. The transition to adulthood for children with cerebral palsy: what do we know about their health care needs? J Pediatr Orthop 2007;27:476-9.
13. Freeman M, Stewart D, Cunningham CE, Gorter JW. “If I had been given that information back then”: An interpretive description exploring the information needs of adults with cerebral palsy looking back on their transition to adulthood. Child Care Health Dev 2018;44:689-96.
14. Gorter JW. Transition to adult-oriented health care: perspectives of youth and adults with complex physical disabilities. Phys Occup Ther Pediatr 2009;29:362-6.
15. Peterson MD, Ryan JM, Hurvitz EA, Mahmoudi E. Chronic conditions in adults with cerebral palsy. JAMA
247

Cerebral Palsy With Aging

16. Cremer N, Hurvitz EA, Peterson MD. Multimorbidity in middle-aged adults with cerebral palsy. Am J Med 2017;130:744.e9-744.e15.

17. Whitney DG, Hurvitz EA, Ryan JM, Devlin MJ, Caird MS, French ZP, et al. Noncommunicable disease and multimorbidity in young adults with cerebral palsy. Clin Epidemiol 2018;10:511-9.

18. van der Slot WM, Roebroeck ME, Nieuwenhuijsen C, Bergen MP, Stam HJ, Burdorf A, et al. Cardiovascular disease risk in adults with spastic bilateral cerebral palsy. J Rehabil Med 2013;45:866-72.

19. Peterson MD, Kamdar N, Hurvitz EA. Age-related trends in cardiometabolic disease among adults with cerebral palsy. Dev Med Child Neurol 2019;61:484-9.

20. McPhee PG, Gorter JW, Cotie LM, Timmons BW, Bentley T, MacDonald MJ. Associations of non-invasive measures of arterial structure and function, and traditional indicators of cardiovascular risk in adults with cerebral palsy. Atherosclerosis 2015;243:462-5.

21. McPhee PG, Gorter JW, Cotie LM, Timmons BW, Bentley T, MacDonald MJ. Descriptive data on cardiovascular and metabolic risk factors in ambulatory and non-ambulatory adults with cerebral palsy. Data Brief 2015;5:967-70.

22. Van Der Slot WM, Nieuwenhuijsen C, Van Den Berg-Emons RJ, Bergen MP, Hilberink SR, Stam HJ, et al. Chronic pain, fatigue, and depressive symptoms in adults with spastic bilateral cerebral palsy. Dev Med Child Neurol 2012;54:836-42.

23. McPhee PG, Brunton LK, Timmons BW, Bentley T, Gorter JW. Fatigue and its relationship with physical activity, age, and body composition in adults with cerebral palsy. Dev Med Child Neurol 2017;59:367-73.

24. Marciniak CM, Lee J, Jesselson M, Gaebler-Spira D. Cross-sectional study of bowel symptoms in adults with cerebral palsy: prevalence and impact on quality of life. Arch Phys Med Rehabil 2015;96:2176-83.

25. Ryan JM, Crowley VE, Hensey O, Broderick JM, McGeheey A, Gormley J. Habitual physical activity and cardiometabolic risk factors in adults with cerebral palsy. Res Dev Disabil 2014;35:1995-2002.

26. Slaman J, Roebroeck M, van der Slot W, Twisk J, Westink A, Stam H, et al. Can a lifestyle intervention improve physical fitness in adolescents and young adults with spastic cerebral palsy? A randomized controlled trial. Arch Phys Med Rehabil 2014;95:1646-55.

27. Slaman J, van den Berg-Emons HJ, van Meeteren J, Twisk J, van Markus F, Stam HJ, et al. A lifestyle intervention improves fatigue, mental health and social support among adolescents and young adults with cerebral palsy: focus on mediating effects. Clin Rehabil 2015;29:717-27.

28. Thorpe D. The role of fitness in health and disease: status of adults with cerebral palsy. Dev Med Child Neurol 2009;51 Suppl 4:52-8.

29. Moll LR, Cott CA. The paradox of normalization through rehabilitation: growing up and growing older with cerebral palsy. Disabil Rehabil 2013;35:1276-83.

30. Andersson C, Mattsson E. Adults with cerebral palsy: a survey describing problems, needs, and resources, with special emphasis on locomotion. Dev Med Child Neurol 2001;43:76-82.

31. Balandin S, Morgan J. Adults with cerebral palsy: what’s happening? J Intellect Dev Disabil 1997;22:109-4.

32. Park MW, Kim WS, Bang MS, Lim JY, Shin HI, Leigh JH, et al. Needs for medical and rehabilitation services in adults with cerebral palsy in Korea. Ann Rehabil Med 2018;42:465-72.

33. Claridge EA, McPhee PG, Timmons BW, Martin Ginis KA, MacDonald MJ, Gorter JW. Quantification of physical activity and sedentary time in adults with cerebral palsy. Med Sci Sports Exerc 2015;47:1719-26.

34. van der Slot WM, Roebroeck ME, Landkroon AP, Terburg M, Berg-Emons RJ, Stam HJ. Everyday physical activity and community participation of adults with hemiplegic cerebral palsy. Disabil Rehabil 2007;29:179-89.

35. Ryan JM, Cassidy EE, Noorduyn SG, O’Connell NE. Exercise interventions for cerebral palsy. Cochrane Database Syst Rev 2017;6:CD011660.

36. Gorter JW. Physical activity interventions for children and young people with cerebral palsy. Dev Med Child Neurol 2017;59:990-1.

37. Verschuren O, Smorenburg AR, Luiking Y, Bell K, Barber L, Peterson MD. Determinants of muscle preservation in individuals with cerebral palsy across the lifespan: a narrative review of the literature. J Cachexia Sarcopenia Muscle 2018;9:453-64.

38. Peterson MD, Haapala HJ, Chaddha A, Hurvitz EA. Abdominal obesity is an independent predictor of...
serum 25-hydroxyvitamin D deficiency in adults with cerebral palsy. Nutr Metab (Lond) 2014;11:22.

39. Whitney DG, Hurvitz EA, Devlin MJ, Caird MS, French ZP, Ellenberg EC, et al. Age trajectories of musculoskeletal morbidities in adults with cerebral palsy. Bone 2018;114:285-91.

40. Mus-Peters CT, Huisstede BM, Noten S, Hitters MW, van der Slot WM, van den Berg-Emons RJ. Low bone mineral density in ambulatory persons with cerebral palsy: A systematic review. Disabil Rehabil 2018 May 22 [Epub]. https://doi.org/10.1080/09638288.2018.1470261.

41. Peterson MD, Zhang P, Haapala HJ, Wang SC, Hurvitz EA. Greater adipose tissue distribution and diminished spinal musculoskeletal density in adults with cerebral palsy. Arch Phys Med Rehabil 2015;96:1828-33.

42. Trinh A, Wong P, Fahey MC, Brown J, Churchyard A, Strauss BJ, et al. Musculoskeletal and endocrine health in adults with cerebral palsy: new opportunities for intervention. J Clin Endocrinol Metab 2016;101:1190-7.

43. Barrett RS, Lichtwark GA. Gross muscle morphology and structure in spastic cerebral palsy: a systematic review. Dev Med Child Neurol 2010;52:794-804.

44. Tosi LL, Maher N, Moore DW, Goldstein M, Aisen ML. Adults with cerebral palsy: a workshop to define the challenges of treating and preventing secondary musculoskeletal and neuromuscular complications in this rapidly growing population. Dev Med Child Neurol 2009;51 Suppl 4:2-11.

45. Benner JL, Hilberink SR, Veenis T, Stam HJ, van der Slot WM, Roebroeck ME. Long-term deterioration of perceived health and functioning in adults with cerebral palsy. Arch Phys Med Rehabil 2017;98:2196-2205. e1.

46. Bottos M, Feliciangeli A, Sciuto L, Gericke C, Vianello A. Functional status of adults with cerebral palsy and implications for treatment of children. Dev Med Child Neurol 2001;43:516-28.

47. Parkinson KN, Dickinson HO, Arnaud C, Lyons A, Colver A; SPARCLE group. Pain in young people aged 13 to 17 years with cerebral palsy: cross-sectional, multicentre European study. Arch Dis Child 2013;98:434-40.

48. Verschuren O, McPhee P, Rosenbaum P, Gorter JW. The formula for health and well-being in individuals with cerebral palsy: physical activity, sleep, and nutrition. Dev Med Child Neurol 2016;58:989-90.

49. Slaman J, Bussmann J, van der Slot WM, Stam HJ, Roebroeck ME, van den Berg-Emons RJ, et al. Physical strain of walking relates to activity level in adults with cerebral palsy. Arch Phys Med Rehabil 2013;94:896-901.

50. Park EY, Kim WH. Prevalence of secondary impairments of adults with cerebral palsy according to gross motor function classification system. J Phys Ther Sci 2017;29:266-9.

51. Jameson R, Rech C, Garreau de Loubresse C. Cervical myelopathy in athetoid and dystonic cerebral palsy: retrospective study and literature review. Eur Spine J 2010;19:706-12.

52. Furuya T, Yamazaki M, Okawa A, Misawa S, Sakuma T, Takahashi H, et al. Cervical myelopathy in patients with athetoid cerebral palsy. Spine (Phila Pa 1976) 2013;38:E151-7.

53. Harada T, Ebara S, Anwar MM, Okawa A, Kajiura I, Hiroshima K, et al. The cervical spine in athetoid cerebral palsy: a radiological study of 180 patients. J Bone Joint Surg Br 1996;78:613-9.

54. Monbaliu E, Himmelmann K, Lin JP, Ortibus E, Bonouvrie L, Feys H, et al. Clinical presentation and management of dyskinetic cerebral palsy. Lancet Neurol 2017;16:741-9.

55. Lee YJ, Chung DS, Kim JT, Bong HJ, Han YM, Park YS. Surgical treatments for cervical spondylotic myelopathy associated with athetoid cerebral palsy. J Korean Neurosurg Soc 2008;43:294-9.

56. Watanabe K, Hirano T, Katsumi K, Ohashi M, Shoji H, Yamazaki A, et al. Surgical outcomes of posterior spinal fusion alone using cervical pedicle screw constructs for cervical disorders associated with athetoid cerebral palsy. Spine (Phila Pa 1976) 2017;42:1835-43.

57. Yi YG, Kim K, Yi Y, Choi YA, Leigh JH, Bang MS. Botulinum toxin type A injection for cervical dystonia in adults with dyskinetic cerebral palsy. Toxins (Basel) 2018;10:E203.

58. Somerville H, Tzannes G, Wood J, Shun A, Hill C, Arrowsmith F, et al. Gastrointestinal and nutritional problems in severe developmental disability. Dev Med Child Neurol 2008;50:712-6.

59. Balandin S, Hemsley B, Hanley L, Sheppard JJ. Under-
standing mealtime changes for adults with cerebral palsy and the implications for support services. J Intellect Dev Disabil 2009;34:197-206.
60. Seo HG, Yi YG, Choi YA, Leigh JH, Yi Y, Kim K, et al. Oropharyngeal dysphagia in adults with dyskinetic cerebral palsy and cervical dystonia: a preliminary study. Arch Phys Med Rehabil 2019;100:495-500.e1.
61. Nieuwenhuijsen C, Donkervoort M, Nieuwstraten W, Stam HJ, Roebroeck ME; Transition Research Group South West Netherlands. Experienced problems of young adults with cerebral palsy: targets for rehabilitation care. Arch Phys Med Rehabil 2009;90:1891-7.
62. Andren E, Grimby G. Dependence and perceived difficulty in activities of daily living in adults with cerebral palsy and spina bifida. Disabil Rehabil 2000;22:299-307.
63. Jahnsen R, Villien L, Egeland T, Stanghelle JK, Holm I. Locomotion skills in adults with cerebral palsy. Clin Rehabil 2004;18:309-16.
64. Hanna SE, Rosenbaum PL, Bartlett DJ, Palisano RJ, Walter SD, Avery L, et al. Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Dev Med Child Neurol 2009;51:295-302.
65. Tan SS, van der Slot WM, Ketelaar M, Becher JG, Dallmeijer AJ, Smits DW, et al. Factors contributing to the longitudinal development of social participation in individuals with cerebral palsy. Res Dev Disabil 2016;57:125-35.
66. Tan SS, Wiegerink DJ, Voos RC, Smits DW, Voorman JM, Twisk JW, et al. Developmental trajectories of social participation in individuals with cerebral palsy: a multicentre longitudinal study. Dev Med Child Neurol 2014;56:370-7.
67. Verhoef JA, Bramsen I, Miedema HS, Stam HJ, Roebroeck ME; Transition and Lifespan Research Group South West Netherlands. Development of work participation in young adults with cerebral palsy: a longitudinal study. J Rehabil Med 2014;46:648-55.
68. Schiariti V, Tatla S, Sauve K, O’Donnell M. Toolbox of multiple-item measures aligning with the ICF Core Sets for children and youth with cerebral palsy. Eur J Paediatr Neurol 2017;21:252-63.
69. van der Slot WM, Nieuwenhuijsen C, van den Berg-Emons RJ, Wensink-Boonstra AE, Stam HJ, Roebroeck ME, et al. Participation and health-related quality of life in adults with spastic bilateral cerebral palsy and the role of self-efficacy. J Rehabil Med 2010;42:528-35.
70. Usuba K, Oddson B, Gauthier A, Young NL. Changes in gross motor function and health-related quality of life in adults with cerebral palsy: an 8-year follow-up study. Arch Phys Med Rehabil 2014;95:2071-2077.e1.
71. Tan SS, van Meeteren J, Ketelaar M, Schuengel C, Reinders-Messelink HA, Raat H, et al. Long-term trajectories of health-related quality of life in individuals with cerebral palsy: a multicenter longitudinal study. Arch Phys Med Rehabil 2014;95:2029-39.