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**Original Article**

# Effects of exercise in people with cerebral palsy. A review.

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**Abstract:**
Regardless the advances in medical science, it seems that the prevalence of cerebral palsy (CP) has been increasing during the last forty years. Cerebral palsy is associated with muscle weakness and impaired circulation that leads to muscle spasticity and deficits in motor control, thereby limiting the individual's ability to perform not only leisure, social or occupational activities but also basic daily tasks. In this sense, exercise is gaining popularity as an intervention choice for this population. Literature aiming to improve the quality of life of patients suffering from cerebral pathologies such as cerebral palsy has observed that both strength and aerobic training lead to significant benefits that improve the quality of life of these patients via a reduction in dependency, muscular deficits and improved cardiorespiratory capacity.
**Key words:** cerebral palsy, strength, aerobic, training..

## Introduction

The cerebral palsy (CP) is defined as a group of disorders that lead to deleterious effects of the body posture and locomotion as a result of an alteration of the central nervous system (Bax, Flodmark, & Tydeman, 2007; Chang, Han & Tsai, 2013; Diez-Alegre & Cuerda, 2012). This pathology is the most frequent cause of physical disability in children (Balemans et al., 2013; Chen et al., 2012; Reddihough & Collins, 2003), with an incidence of 2-3 cases of CP per 1,000 live born children (Himmelman, Hagberg, Beckung, Hazberg & Uvebrant, 2005). Every year there are approximately 10,000 newborns diagnosed with CP in Europe (Surveillance of Cerebral Palsy in Europe, 2002) and compared with 17 leading causes of congenital disorders, the total medical costs of CP exceed all other diagnoses (Economic costs associated with mental retardation, 2003). The prevalence of CP not only has not decreased, but some authors argue that in the past forty years it has even increased (Odding, Roebroek & Stam, 2006). The deficits associated with this syndrome include spasticity, a decreased selective motor control and higher coactivation that lead to impaired functional abilities (Bryant, Pountney, Williams & Edelman, 2012; Hurkmans, van den Berg-Emons & Stam, 2010; Lundberg, 1984). Consequently, individuals with CP tend to be sedentary, which results in a greater risk for muscle weakness, poor functional strength, decreased endurance, impaired circulation, limited fine motor control and range of motion, poor bone density, fractures, respiratory, cardiac and digestive problems, and a reduced sense of independence (Chang et al., 2013; Durstine et al., 2000; Fowler et al., 2007; Houlihan & Stevenson, 2009). As a result of these disorders, people with CP have a reduced physical fitness, which is related to a lower health status and well-being as well as to the development of other pathologies such as obesity or diabetes (Balemans et al., 2013; Hurkmans et al., 2010; Schuit, Feskens, & Seidell, 1999; Stewart et al., 1994). In this sense, a reduction in the motor abilities may also contribute to or possibly be the result of physical inactivity and, as a result, may affect the individual's ability to perform daily tasks, to participate in community and leisure activities and negatively impact occupational perspectives (Byun et al., 2010; Chang et al., 2013).

In this population, adequate physical and psychological rehabilitation plays a major role, aiming to reduce the potential limitations produced by the neurological alterations. In this context, physical exercise becomes an essential tool to enhance the motor autonomy, independence and social inclusion of CP patients, and therefore it should be considered one of the strategies with more potential in the years to come. On this basis, the present work aims to show how physical exercise may affect people with CP.

## Method

This systematic search was focused on the literature pertaining to the effect of exercise on the health of patients with cerebral palsy. For this systematic review, an extensive literature search was conducted using MEDLINE (PubMed), CINAHL, Sport Discus, Science Direct, PEDro and Google Scholar electronic databases with no year, gender, age or type of article restriction. The key words used in the online search included


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“cerebral”, “palsy”, ”exercise”, “training”, “aerobic”, “cardiorespiratory”, “strength”, and “resistance”. Boolean operators, ‘OR’ and ‘AND’ were used to combine within and between the search terms of the subject areas.

**Results**

The search strategy and article screening process are illustrated in Figure 1. Our search yielded 642 articles, and a final selection of 64 articles which were considered relevant was done to fit the objectives of the study. Among the 64 studies, 56 were research articles and the 8 remaining papers were reviews.

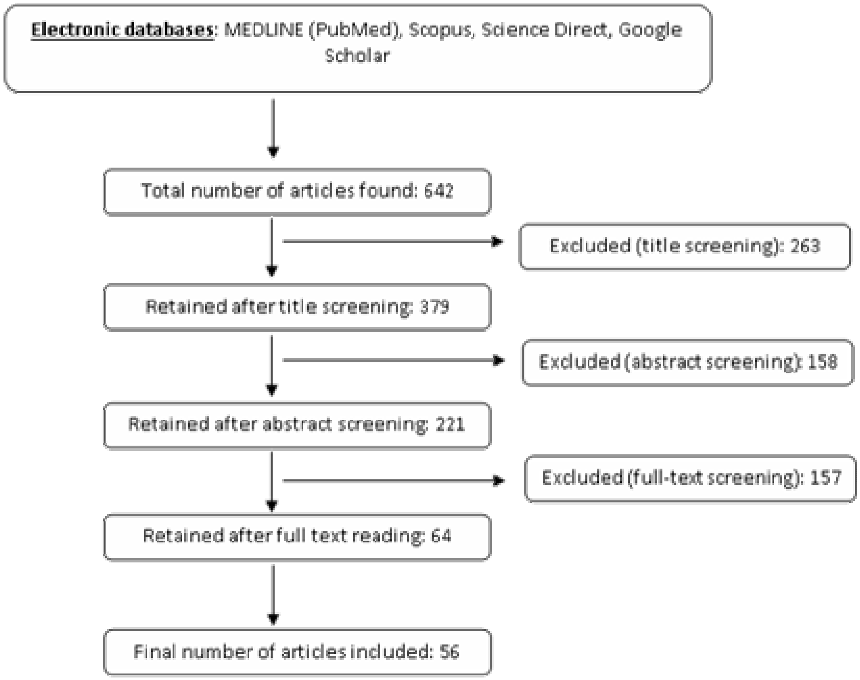


Fig 1. Search process.

**Discussion**

**Physical exercise effects on people with cerebral palsy**

Physical inactivity in people with Cerebral Palsy (CP), in the same way as it occurs in the population without this pathology, may produce a deconditioning of the muscular, skeletal and cardiorespiratory systems, which contributes to a vicious cycle that deteriorates the disability level (Maher, Williams, Olds, & Lane, 2007). It is important to take into account that a minimum level of motor activity is essential in order to interact with the environment (Bjornson et al., 2007). In individuals with cognitive disorders such as CP, experiencing difficulties in movement can have serious deleterious effects on cognitive, emotional and social development (Damiano, 2006; Hughes, 1984; Taylor, Sallis, & Needle, 1985). Recent advances in neuroscience have demonstrated the importance of motor activity for the establishment and strengthening of neural connections, whereas these benefits are reversed when the activity is reduced (Bryan et al., 2012; Damiano, 2006).

In patients with CP there is an evident deficiency of motor control as a result of the development of the brain injury (Damiano, 2006; Gaskin & Morris, 2008). A low level of fitness in people with CP contributes to the development of chronic pain, fatigue and osteoporosis (Fowler et al., 2007). People with CP need to exercise regularly in order to maintain their muscle length and strength (Tardieu, Tardieu, Colbeau-Justin, & Lespargot, 1982). As occurs in people without this pathology, CP patients need to work under compressive loads to maintain the individual’s bone density levels and exercise their cardiorespiratory system to maintain their strength and fitness levels (Damiano, 2006; Marques et al., 2011). In children with CP, exercise is even more important since the pathology develops when the structures and organs are not yet fully developed (Damiano, 2006). In this sense, previous evidence supports that the lack of physical condition in young people with CP results in a relevant deficiency of the walking ability and independence (Damiano, 2006, DiBiasio & Lewis, 2012).

Although CP is often related to disorders with different etiologies and manifestations, in most of them there is no cure. Consequently, some of the interventions with physical training programs have shown modest results (Bryan et al., 2012; Chang et al., 2013; Chen et al., 2012; Damiano, 2006; Dodd, Taylor & Graham, 2003; Mattern-Baxter, McNeil & Mansoor, 2013). However, many of these studies consisted of short-term programs which may have not been long enough to produce adaptations. For this reason, longer physical programs are needed in order to really understand how exercise can benefit and improve the quality of life of people with CP.

Rehabilitation of CP has been commonly divided into rehabilitation of the upper and lower limbs (Damiano, 2006). Rehabilitation of the upper limbs has been associated with fine motor tasks, exercises performed in a unilaterally way, and coordination exercises using both arms (Damiano, 2006; Diez-Alegre et al., 2012; Howcroft et al., 2012; Huber et al., 2010; Hutzler, Lamela-Rodríguez, Laiz-Mendoza, Díez, & Barak, 2013). These tasks have been proven effective in the treatment of CP and other central nervous system disorders such as hemiplegias (Dean and Shepherd, 1997; Taub, Ramey, DeLuca & Echols, 2004). On the other hand, lower limb rehabilitation generally consists on gross motor activities involving repetitive and coordinated movements with both limbs (walking, cycling, etc.), what sometimes does not require a conscious effort (Balemans et al., 2013; Bryant et al., 2012; Chen et al., 2012; Damiano, 2006; Leunkeu, Shepard & Ahmaidi, 2012; Mattern-Baxter et al., 2013), resulting in improvements in gait performance and gross motor ability (Baxter et al., 2013; Damiano, 1995; DiBiaso & Lewis, 2013; Johnson et al., 2011; Willoughby, Dodd, Shields & Foley, 2010). However, it is necessary to distinguish between the different types of training (strengthening, aerobic training) in order to provide a clearer picture of how each training modality may benefit people with CP.

***Strength training effect***

Although strength training was initially contraindicated because it was believed to stiffen muscles, resulting in an increase in spasticity and a decrease in range of motion (Bobath, 1971), current scientific evidence dictates the contrary (Andersson, Grooten, Hellsten, Kaping & Mattsson, 2003; Damiano, 2006; Dodd, Taylor & Damiano, 2002; Engsberg, Ross & Collins, 2006; MacPhail & Kramer, 1995). In the last decade, the strength training as part of the physical therapy has become more frequent due to the positive results of different studies (Andersson et al., 2003; Blundell, Sheperd, Dean, Adams & Cahill, 2003). Firstly, it is necessary to describe the differences observed in a muscular level between people with and without CP. Different studies observed disorders in the recruitment of muscle strength in people with CP. Stackhouse et al. (2005) found that children with CP produced 57% and 73% less force in knee extension and ankle plantar flexion compared to children without CP, respectively. Additionally, they also obtained deficits in muscle activation and found a 39% reduction in the quadriceps femoris and 49% in the triceps surae activation. Finally, these authors observed that the co-activation of antagonistic muscles was excessive in children with CP, resulting in a decrease in force production in the knee (Stackhouse et al., 2005).

Rose and colleagues (2005) reported an abnormal variation in the size of muscle fibres and an alteration of the distribution in the types of fibres in children with CP. The size of the muscle fibres in children with CP was greater compared to children without CP. Children with CP also presented a 67% predominance of one fibre type compared with a 55% predominance in the control subjects (Rose et al., 2005). The difference between the total area of type-1 and type-2 fibres was 57% in the subjects with CP and 17% in the control subjects (Rose et al., 2005). These differences in fibre area were correlated with a different energy expenditure rate and muscle activity compared to the control subjects during walking (Rose et al., 2005). Furthermore, Fowler and colleagues (2007) reported greater weakness in the distal musculature in comparison with the proximal musculature in people with CP, difference that may be responsible for the difficulties in locomotion that CP patients suffer. As a result of this difference in muscular strength, a study reported that 51% of the subjects with CP analysed in that work could not walk or needed orthopaedic help to carry out the task (Andersson & Mattsson, 2001).

In a systematic review by Dodd et al. (2002), up to ten studies showed consistent and significant strength improvements both in the upper and lower limb in people with CP as a result of various short-term programs. Furthermore, they also provided evidence which indicated that muscle spasticity was not deteriorated as a result of strength training in adults with CP (Andersson et al., 2003). Blundell et al. (2003) carried out a training program with children with CP that consisted of a physical circuit composed of tasks such as treadmill walking, step-ups, sit-to-stands and leg presses. This program was carried out for 4 weeks with a frequency of 2 sessions/week for 1 hour, what provoked significant improvements in strength and functional performance of children with CP (Blundell et al., 2003). An alternative method to improve muscle strength is the electrical stimulation. This method may be more attractive because it provokes muscle contractions without any voluntary control (Fowler et al., 2007). However, Kerr and colleagues (2004) did not find conclusive evidence regarding the effectiveness of this method in people with CP.

***Aerobic training effect***

Negative effects on a muscular level have cardiorespiratory consequences. People with CP may have problems when executing movements because their muscular activation is deteriorated (Fowler et al., 2007). Consequently, their lower muscle activation may limit their ability to exercise in the adequate intensity and reduce the cardiorespiratory adaptations that normally accompany exercise (Fowler et al., 2007).

On the other hand, it is also necessary to discuss the differences observed on a cardiorespiratory level between people with and without CP. Bowen et al. (1998) investigated oxygen uptake between children with CP and without CP during walking, and they did not find differences between the two groups. However, other studies have observed that children with CP have lower cardiorespiratory fitness levels, showing low levels of

$VO_{2máx}$ and higher energy demands in a submaximal exercise such as walking (Hoofwijk, Unnithan & Bar-Or, 1995; Unnithan , Clifford & Bar-Or, 1998). This lower cardiorespiratory level can result in reduced overall health and well-being (Fowler et al., 2007). Energy demand during locomotion increases with age in children with CP, resulting in difficulties to maintain their aerobic capacity during walking, especially during the transition from adolescence to adulthood (Fowler et al., 2007). Furthermore, it has been observed that these children consume a greater amount of energy during running at medium speeds compared to children without CP (Unnithan et al., 1998; van den Berg-Emons, Saris, Barbanson, Westerterp, Huson & van Baak, 1995).

Currently, well-designed studies that show how aerobic exercise affects people with CP are necessary. One of the first studies addressing this issue was performed by Berg (1970), who showed that three sessions of 20 minutes a week of aerobic exercise were able to produce improvements in oxygen uptake and blood hemoglobin levels in children with CP (Berg, 1970). Pitetti and colleagues (1991) found that aerobic exercise with ergometric stations for the upper body increased $VO_{2máx}$ by approximately 12%. Swimming can also be a good choice to improve fitness in people with CP because not only it reduces impacts and stress on joints, but it also attenuates the negative effects of inadequate postural control and improper balance (Kelly and Darrah, 2005). In aquatic exercises, Kelly and Darrah (2005) obtained improvements in flexibility, respiratory function, muscle strength and motor coordination in children with CP. Similarly, Bar-Or et al. (1976) also observed increases of 8% in $VO_{2máx}$ as a result of aquatic aerobic exercise in people with CP.

**Conclusion**

People with CP have significant deficiencies in muscle strength and cardiorespiratory capacity. The differences in participant's characteristics, duration, intensity and type of training program, as well as the different study protocols used in the literature makes it difficult to provide a comprehensive and conclusive statement. However, from a critical evaluation of the data currently available, it seems that strength and aerobic training in people with CP provoke important benefits that can lead to improvements in quality of life by reducing dependence and muscle deficits, and by improving their cardiorespiratory fitness as well as their ability to perform daily-life activities.

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