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Physical activity in the treatment of cardiorespiratory disorders for children with cerebral palsy

Master Thesis

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Declarations

I declare that this study is my own work and it was done and conducted by myself only. The study was under the close supervision of PhDr. Tereza Nováková, Ph.D.

I would also like to confirm that this study was neither submitted nor published to obtain any degree or title at any university.

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Abstract

Children with cerebral palsy have lesser cardiorespiratory endurance (or aerobic capacity) and less physical activity than children who are developing normally. Cardiorespiratory problems are linked to a higher risk of noncommunicable diseases and premature aging. The goal of this research is to discover aspects that can be added in physiotherapy practice to ensure a long-term improvement in aerobic capacity in children with cerebral palsy while engaging in physical activity. Also investigated is the effect of aerobic capacity on functional abilities. A systematic review of the literature was undertaken utilizing the PubMed, Cochrane Library, ScienceDirect, and PEDro databases. The child's cardiorespiratory fitness appears to improve when they engage in high-intensity, goal-directed physical activity. The child's adherence appears to be aided by a motivating intervention and the removal of environmental barriers to the activity's practice. This allows for a long-term increase in aerobic capacity. It was impossible to draw a direct link between this improvement and functional capacity. Few studies have incorporated cerebral palsy and low global motor skills in recent years. Despite the importance of the findings, their heterogeneity prevents generalizable suggestions for all children with cerebral palsy. It is critical to take steps to increase physical exercise. Measurement tools appropriate to every child with cerebral palsy are also advised in order to ensure that the sessions are rigorously evaluated on a regular basis. These will improve in effectiveness and reliability.

Keywords: cerebral palsy, aerobic capacity, physical activity, prevention

Abstrakt

Děti s dětskou mozkovou obrnou mají menší kardiorespirační vytrvalost (nebo aerobní kapacitu) a méně fyzické aktivity než děti, které se vyvíjejí normálně. Kardiorespirační problémy jsou spojeny s vyšším rizikem nepřenosných nemocí a předčasným stárnutím. Cílem tohoto výzkumu je objevit aspekty, které lze přidat do praxe fyzioterapie k zajištění dlouhodobého zlepšení aerobní kapacity u dětí s dětskou mozkovou obrnou při fyzické aktivitě. Zkoumán je také vliv aerobní kapacity na funkční schopnosti. Byla provedena systematická revize literatury s využitím databází PubMed, Cochrane Library, ScienceDirect a PEDro. Zdá se, že kardiorespirační zdatnost dítěte se zlepšuje, když se věnuje vysoké intenzitě cílené fyzické aktivity. Zdá se, že adherenci dítěte napomáhá motivující intervence a odstraňování environmentálních bariér v praxi dané činnosti. To umožňuje dlouhodobé zvýšení aerobní kapacity. Bylo nemožné vytvořit přímou souvislost mezi tímto zlepšením a funkční kapacitou. Několik studií zahrnovalo v posledních letech mozkovou obrnu a nízkou globální motoriku. I přes důležitost těchto zjištění jejich heterogenita brání zobecnitelným návrhům pro všechny děti s dětskou mozkovou obrnou. Je důležité podniknout kroky ke zvýšení tělesného cvičení. Doporučují se také měřicí nástroje vhodné pro každé dítě s dětskou mozkovou obrnou, aby bylo zajištěno pravidelné pečlivé hodnocení sezení. Zlepší se tak účinnost a spolehlivost.

Klíčová slova: dětská mozková obrna, aerobní kapacita, fyzická aktivita, prevence

1. Introduction

Cerebral palsy is a group of permanent neurodevelopmental disorders, resulting from an injury on a developing brain. This is the first form of childhood disability with a prevalence rate of 2 to 3.5 per 1000 births alive in Europe. Among the associated disorders, impaired respiratory function is the leading cause of death in this population. From an early age, the troubles of cardiorespiratory diseases are associated with an increased risk of noncommunicable diseases, which nearly re the two-thirds of deaths worldwide.

Nowadays, in order to prevent cardiorespiratory mismatch in adulthood, recommendations encourage the reduction of sedentary behavior of the child cerebral palsy, as well as regular intensive physical activity. This appears relevant in a public health policy context focused on the actions of prevention. However, these guidelines do not cover clinical conditions of application, nor the elements favoring the sustainable follow-up of these recommendations. The following problem has then formulated: **Taking into account the cardiorespiratory disorders presented by the cerebral palsy child, as well as increased sedentary behavior, how the the physiotherapist can ensure a lasting improvement of the aerobic capacity, through physical activity?**

The following conceptual framework sets out the necessary knowledge to understand the cardiorespiratory disorders and the challenges of their management in the children with cerebral palsy.First, cerebral palsy will be defined, as well as the different classifications and clinical pictures encountered. The rest of this writing will set out in detail the questioning which gave rise to the literature review. Then the methodology used will be described before the synthesis of the research results. The discussion will discuss the different methods of therapy likely to sustainably improve the cardiorespiratory capacity in children with cerebral palsy, as part of physical activity. The relationship between improvement of aerobic capacity, and that of functional capacity will be also discussed. Finally, the limits of this work will be highlighted, and the conclusion will try to open the reflection on the possible follow-up to be given to this duty.

Data has been taken and filtered from four different databases: PEDRO, PUBMED, SCIENCE DIRECT and COCHRANE LIBRARY.

The research was made under the keywords of cerebral palsy; children; rehabilitation; program; intervention, physical activity; exercise training; cardiorespiratory; fitness; aerobic to get the highest possible number of results. from that point 11 papers were chosen to work with. It is going to be a systemic review based on this 11 papers found regarding the topic. The papers found are randomized controlled trials to help get the highest level of evidence and the best possible results to come up with a conclusion showing the importance of physical activity in the treatment of cardiorespiratory disorders for children with cerebral palsy.

2. Theoretical background

2.1. Cerebral palsy

2.1.1. Definition

The definition for identifying movement and postural disorders in children has progressed for more than three centuries due to the complexity of the pathology affecting the brain at varying degrees and severity of functional consequences.

In the 18th century, Lallemand (1820), Cazauvieilh (1827), two French doctors (Ingram, 2000) had already shown links between brain damage and the clinical manifestations. However, it is recognized that it was Little (Little, 1843) in 1843 and 1862 who, by his numerous studies on CP, laid the foundations for a definition by emphasizing retractions and deformities result from spasticity and long-lasting paralysis (Little et al., 1958).

By the middle of the 20th century, many authors such as Crothers (1951), Phelps (1941) in United States and Mac Keith and Polani (1959), Bax (1964) in England worked on the definition of the CP. Mac Keith and Polani, (1959) defined cerebral palsy (Cerebral paralysis) non-progressive brain damage that occurs in the early stages of life and inducing permanent disorders of posture and movement which manifests itself in the very early childhood (Mac Keith et al., 1959). Bax, (1964) traces the appearance of lesions back in time cerebral lesions including lesions of the immature brain, that is to say lesions that have occurred unnecessary. However, he excluded short-term movement disorders, progressive pathologies or those related to a mental deficiency (Bax, 1964).

In 2000 the CP Monitoring Group in Europe published the standard procedures to describe with certainty what CP is. In the new definition of CP they took over essentially the proposals of Mutch et al. (1992) which include the following 5 key points (Mutch et al., 1992):

- CP is a generic term, in a way a “hat”.
- CP is permanent but the sequelae can evolve because they depend on many factors: growth, musculo-articulo-tendon modifications (retraction,osteo-articular deformity), etc.
- CP involves disorders of motor functions and in particular of posture and of displacement.

- CP is due to acquired brain damage that is not progressive and abnormalities progressive (such as stiffness of the limbs which is the consequence of the initial lesion of the brain causing disruption of the motor functions of the limbs).
- CP includes interference between lesions related to an immature brain. (Bax et al., 2005) (Bax et al., 2006) added to the definition of PC the disorders of sensitivity, perception, cognition,communication, behavior, epilepsy and secondly, musculoskeletal problems.

Following a workshop, the Executive Committee,Rosenbaum et al , presented a report on the definition and classification of CP with the following terms:

Cerebral palsy is a group of permanent disorders of movement and posture that leads to limitation of motor activities following non-progressive lesions occurring in the developing brain of the fetus or infant. Motor disorders in CP are often accompanied by disturbances in sensitivity, perception, cognitive function, communication, behavior through epilepsy and secondarily by musculoskeletal problems (Rosenbaum et al., 2007).

In France, Tardieu G., neurologist, defined in 1954 "Cerebral Palsy as a motor sequelae of an accidental brain injury occurring in the "peri-natal" period. That is, sometimes "before" (in utero), sometimes at the time of birth, sometimes just after. It is therefore a neonatal suffering, not progressive and not curable. He spread from CP the malformations causing progressive brain damage. He distinguished two CP forms , the first presents with motor disorders without intellectual delay, and the second, called Cerebral Palsy of Cerebral Origin (IMOC) where motor disorders are more severe and which combines impairment of higher functions such as intellectual retardation (Tardieu et al., 1954).

Today the scientific community prefers to use the term Cerebral Palsy which is the name adopted by almost all countries. The term PC is more general since it also groups together the forms with intellectual impairments where we speak in the most severe cases of multiple handicapped.

2.1.2. Epidemiology

With an estimated prevalence rate of 2 to 3.5 per 1000 live births in Europe, the Cerebral palsy is the most common form of childhood disability nowadays. Geographic location, birth weight and gestational age are factors influencing the prevalence of this pathology. Despite improved prenatal and perinatal care ,the overall number of children with cerebral palsy has hardly changed over the past 40 years. The stability of the prevalence can be explained in particular by better survival of very premature babies (Eunson, 2012).

2.1.3. Etiology and risk factors

By definition, neurological damage in children with cerebral palsy (CP) affects a brain while its development. Brain damage can occur during the prenatal periods, perinatal and postnatal. These so-called early lesions systematically occur before age 2 years. Despite the application of increasingly comprehensive assessments, the origin of the handicap remains uncertain in about 25% of children with disabilities (Bérard, 2008). Nevertheless, many risk factors have been identified and classified according to the period in which they occur in the following table:

Period	Etiology	Proportion (cp)
prenatal	• Brain malformations • Stroke • Sequelae of fetal-maternal infections • Maternal drug and alcohol abuse • Maternal epilepsy • Radiation exposure	70-80%
Perinatal	• Asphyxia • Anoxic ischemic encephalopathy • Prematurity and low birth weight • Intraventricular bleeding • kernicterus	10-20%
Postnatal	• Meningitis/ Encephalitis • Head trauma • Treatment of brain tumor • seizures	

Table 1. Distribution of etiologies of cerebral palsy children according the period of the lesion (Palisano et al., 1997)

Often, the addition of these factors impacts brain maturation. We are then in front of multifactorial origin. However, the most frequent etiologies remains anoxia ischemic, prematurity (found in 45% of cases of CP), and low birth weight. Most often, severe impairments in children are of antenatal origin (Palisano et al., 1997).

2.1.4. Diagnosis

The diagnosis is usually made around the age of two (Herskind et al., 2015). A physical examination allows to objectify the existence of a non-progressive motor deficit (Rosenbaum et al., 2007).Neuroimaging techniques such as magnetic resonance imaging (MRI), or Computed tomography (CT) can identify the location of brain lesions and their degree of severity (Viallard et al. , 2016).

But unlike in adults, the attacks cannot define a clinical picture according to injured areas. Indeed, the child's brain being in full evolution and having a significant cerebral plasticity, the repercussion of cerebral palsy are multiple and may be fixed depending on the lesions. Thus, within the cerebral palsy population many clinical pictures are grouped together. Evolution and recovery are intrinsic to everyone.Differential diagnoses are dominated by neurodegenerative pathologies where there is a deficit in motor function (Rosenbaum et al., 2007).

2.1.5. Classifications

In order to devide the wide variety of clinical pictures and degrees of limitations presented by cerebral palsy, classifications are needed to describe, compare and evaluate the evolution (Rosenbaum et al., 2007). Thus, these classifications will guide the rehabilitation of the subject. They are three in number:

- Topographic classification
- Symptomatological classification
- Functional classification

2.1.5.1.Topographic Classification

This classification of cerebral palsy is based on "the number and location of body segments with impaired motor function "(Bax et al., 2005). By order of increasing disability, the topographical classification includes:

- Monoplegia: damage of a single limb
- Hemiplegia: damage of the hemibody contralateral to the brain lesion
- Diplegia or paraplegia: majority damage of both lower limbs

- Triplegia: damage of both lower limbs and one upper limb
- Quadriplegia or tetraplegia: involvement of all four limbs

In 2000, in order to overcome the inaccuracies and the different interpretations of this classification, the organization "Surveillance of Cerebral Palsy in Europe" (SCPE) has proposed an alternative which precises inclusion and exclusion criteria for CP children as well as a clinical classification highlighting the unilateral or bilateral character of CP (Boltshauser, 2015) (Fig. 1)

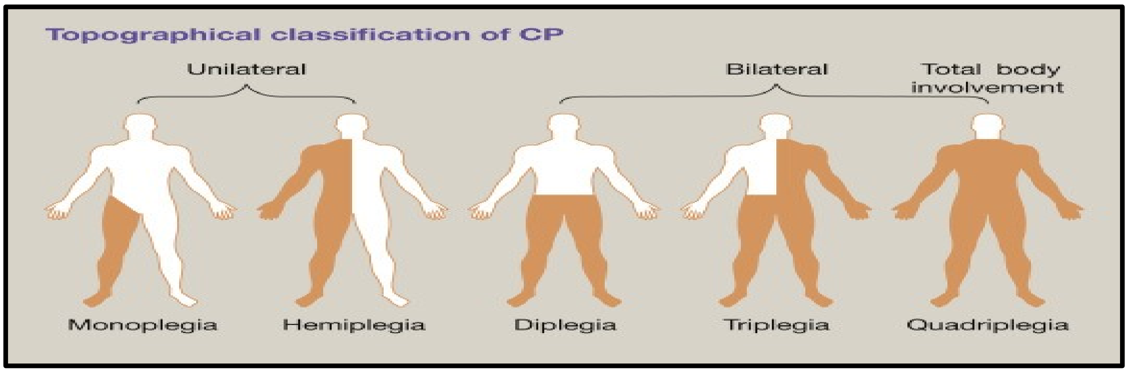

Figure 1. Topographic classification of cerebral palsy (Peterson & Walton, 2016)

2.1.5.2.Symptomatological classification

This classification was established according to the predominant motor disorder, in connection with change in tone (Bérard, 2008) .Thus,depending on the symptomatology, four forms can be distinguished:

- Spastic (85%): unilateral or bilateral, it results from cortical damage
- Dyskinetic (7%): it includes dystonic and choreo-athetotic CP
- Ataxic (5%): due to damage of the cerebellum
- Mixed: it causes intersecting and very heterogeneous clinical pictures, following central nervous system damage.

The understanding of this classification is again variable. In order to facilitate its application, a hierarchical classification tree was described in 2000 by the SCPE (SCPE et al., 2000) (Fig. 2)

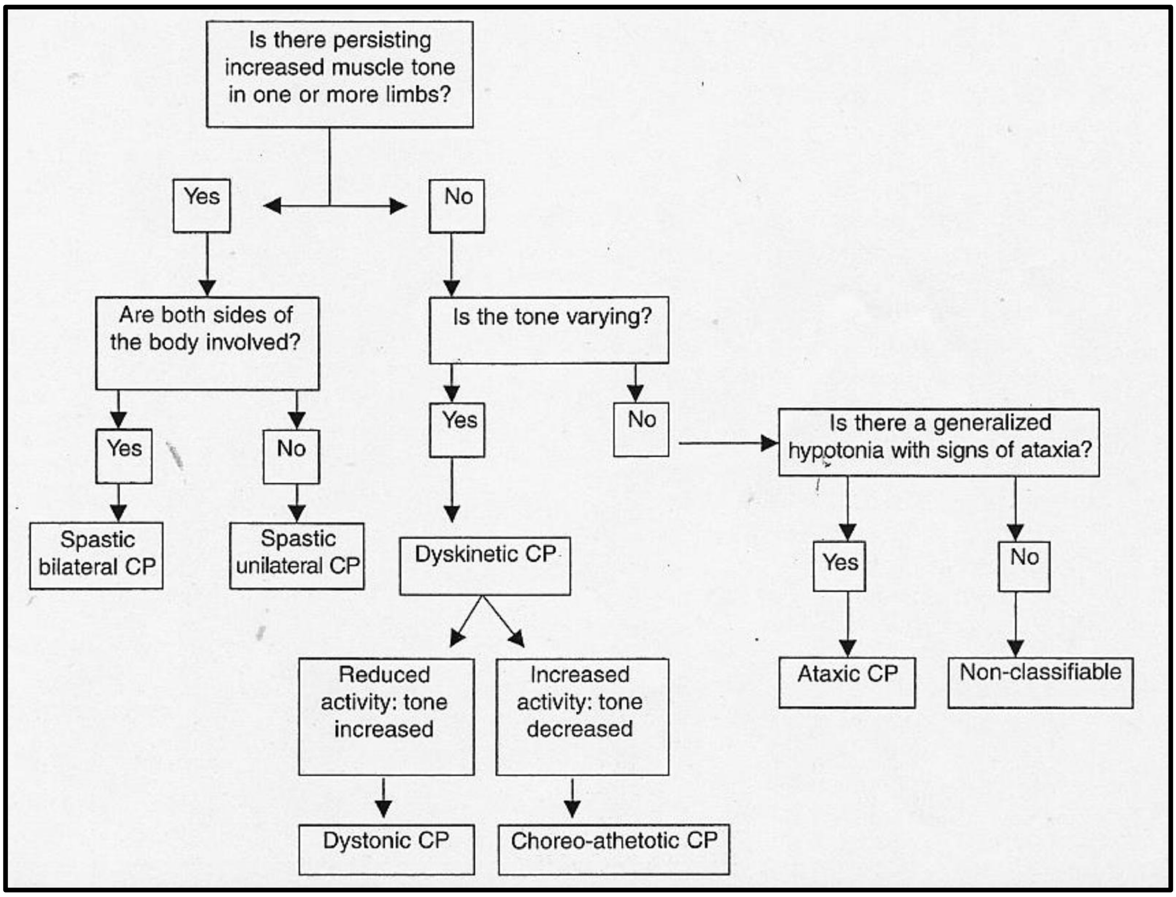

Figure 2. Classification tree of CP subtypes described by CSEP (Smithers et al., 2014)

2.1.5.3. Functional classification

There are different classifications to assess the level of impairment of motor function of a person with cerebral palsy. The severity of the disorders is assessed by functional classifications allowing to report, in a reliable and reproducible way, the child's ability level:

- The Global Motor Function Classification System (or GMFCS): This system established by Palisano in 1997, allows to define the posture and movement capacities of affected children based on of their age. It describes five levels of severity (Palisano, 1997) (Appendix 1).
- The Manual Ability Classification System (MACS): It classifies the CP child according to its way to use his hands in handling everyday objects (Boltshauser, 2015).
- Communication Function Classification System (CFCS): It is used to classify the daily communication performance (Boltshauser, 2015).

- ♦ Eating Drinking Ability Classification System (EDACS): It classifies CP children in according to the way they eat and drink in everyday life (Boltshauser, 2015).

2.1.6. Disorders in CP children

2.1.6.1.Clinical picture

Although linked to the appearance of fixed brain lesions, cerebral palsy is an evolving pathology. In fact, during growth and aging, the primary involvement of the neuromotor pathways progresses towards the development of secondary and tertiary abnormalities. The disorders present in CP child worsen and are usually found in adulthood(Rosenbaum et al., 2007). In this work, the term "child" designates both childhood from 2 to 12 years, and also adolescence from 13 to 21 years old.

Neuromotor disorders	Orthopedic disorders	Specific disorders
➢ Muscle weakness ➢ Motor Disorders ➢ Tone disorders (dystonia, spasticity) ➢ Sensibility Disorders	➢ Retractions and hypo-extensibilities ➢ postural defects (excessive anteversion femoral neck, torsion internal tibial, valgus deformity, varus of some joints, etc.) ➢Static spinal disorders ➢ Anomalies of growth	➢ Epilepsy ➢ Dyspraxia visuospatial ➢ Attentional Difficulties ➢ Cognitive disorders ➢ Respiratory disorders ➢ Dysexecutive disorders ➢ Language disorders oral or written

Table 2. Presentation of the disorders encountered in children with CP (Rosenbaum et al., 2007)

2.1.6.2.Specific disorder : impairment of respiratory function

Respiratory disorders, and in particular respiratory infections are responsible for 50 to 80% of deaths, thus constituting the leading cause of death within the population of cerebral palsy (Durufle et al., 2014). Respiratory morbidity is all the more important as the level GMFCS is high. Thus, despite an improvement in nursing, of prevention and treatment of the associated complications, children with cerebral palsy have a life expectancy shorter than that of other children (Cans, 2000).

The thoracic and spinal deformities found have a direct impact on the development of the lungs and pulmonary alveoli. Therefore, the dynamic thoraco-pulmonary and gas exchange are also disturbed. The result is a restrictive syndrome causing overall hypotrophy, and thoracic growth delay which conditions lung development. According to studies, in children in the general population, the thoracic volume at birth is equivalent to 6% of the adult volume, 30% at 5 years, and 50% at 10 years. At the same time, the rib cage changes from a shape circular to an ovoid shape to facilitate hematosis. These standards are not met in children with cerebral palsy, which leads to an alteration in pulmonary dynamics.

The literature encountered often relates both to the respiratory function of the child PC and children with multiple disabilities in general. In 2009, decree n ° 2009-378 - art. 5, defines the patient polyhandicapped as "suffering from a severe handicap with multiple expression associating a motor impairment, severe or profound mental impairment leading to restriction extreme autonomy and possibilities of perception, expression and relationship (Cole, 2014).

At the Seattle World Congress in 2002, the International Association for the Study Scientist of Intellectual Disabilities (IASSID) defined the term PIMD by "People having a profound mental disability associated with multiple disabilities in particular motor "(Holenweg et al., 2014).

These two definitions therefore make it possible to include the CP patient in the concept of polyhandicap (Cole, 2014). In fact, in the cerebral palsy, the association of neurological disorders and secondary musculoskeletal disorders results in impaired respiratory function (Seddon et al., 2003). The description of the disorders below based on mixed population studies (De La Gastine & Stagnara, 2017), we will therefore refer to the more general notion of polyhandicap.

Motor disorders

- Postural and antigravity

Excessive contractions in the muscles of the neck, shoulders, and trunk cause a limitation of abdominal and thoracic mobility. This leads to positional preferences and malpositions causing upper airway obstruction (UAO), hindering the free passage of air.

- Reflex disorders

Stasis and nasopharyngeal congestion are favored by an alteration of the reflex of swallowing, as well as hypo or areflexia with cough. The children then present a tendency to congestion associated with an ineffective cough as well as a strong propensity to breathe loudly, and to take the wrong path.

- Swallowing and dysphagia

Patients are frequently prone to take the wrong path, fueling inflammation of the the bronchial epithelium and degrading the mucociliary system. The dimensions and atelectasis are thus favored. Dehydration and associated digestive problems can cause gastro-oesophageal reflux or even secondary bronchopulmonary infections likely to interfere with ventilatory efficiency.

- Disadaptation to effort

Many children, adolescents and adults with cerebral palsy have reduced exercise endurance. Indeed, in patients with less motor activity,ventilation adaptation is reduced. Thus, the mobilized lung volumes are limited, and the vital capacity tends to approach the tidal volume.

Trophic disorders

Cerebral palsy resulting in altered tone, bronchial, laryngeal or lungs tissues may be injured. Depending on the area concerned, obstructive noise may be observed during auscultation, inspiration or expiration. Respiratory failure is increased by increased obstruction of air flow during respiratory muscle recruitment. This obstruction can cause the inefficient increase in cardiac and respiratory frequencies, leading to exhaustion, and sometimes even death.

Intellectual deficits

Intellectual and behavioral disorders can lead to inappropriate reactions such as lack of coughing, nose blowing, or insufficient oral moistening. Patient agitation may also limit the application of certain instrumental techniques.

The care of the child begins with automatic relaxation maneuvers. In order to alleviate these disorders, he can then resort to manual techniques such as: nasopharyngeal toilet, postures, thoracic mobilization, or even manual drainage (Increased Expiratory Flow (IEF) or Extended Slow Expiration (ESE). The practitioner also has instrumental techniques. These include: aspiration nasopharyngeal, hyperinsufflation (pressure relaxer), cough aid (CoughAssist,Clearway), or aerosol therapy (Lauglo et al., 2016).

2.1.6.3.Cardiovascular comorbidities

Over the past three decades, there has been a significant increase in morbidity worldwide in relation to noncommunicable diseases (NCDs) (Murray et al., 2014). These now account for nearly two-thirds of deaths worldwide. Causes of death by NCDs are cardiovascular disease, cancer, respiratory disease, including asthma and chronic disease. In total, these four types of disease represent 82% deaths from NCDs (Murray et al., 2014).

In cerebral palsy, studies suggest a phenotype of an early cardiovascular risk (Van Der Slot et al., 2013). In fact, within this population, young adults would present predispositions to hypertension (Ryan et al., 2014) as well as to hyperlipidemia (Peterson et al., 2012). Likewise, the CP adults have less lean body mass, and more body fat relative, compared to the general population (Peterson et al., 2015). These elements should be put in relationship with increased sedentary behavior (Ryan et al., 2014), especially due to a progressive loss of function (Behardien, 2019). In order to alleviate these cardiovascular risk factors, the participation to a higher level of physical activity from an early age is now encouraged (Ryan et al., 2018). As a result, people with cerebral palsy are at increased risk of chronic so-called non-communicable diseases, linked to metabolic rate risk as well as participation in reduced levels of physical activity throughout of their life (Ryan et al., 2014).

We therefore notice the existence of cardiorespiratory disorders present from the youngest age within this population. In a second part, we will define these disorders as than the axes of treatment existing to date.

2.2.Cardiorespiratory disorders

2.2.1. Definitions

2.2.1.1.Physical capacity

Health-related physical capacity is the ability to perform physical activity (Ferguson, 2014). It involves a set of attributes specific to the individual such as: cardiorespiratory endurance, body composition, muscle strength, muscle endurance and flexibility (Ferguson, 2014).

Optimal physical capacity therefore includes the integrity of these attributes. The failure of any of these parameters may be associated with an increased risk of chronic disease, in relationship with reduced physical activity.

2.2.1.2.Cardiorespiratory capacity:

Cardiorespiratory capacity or aerobic fitness is an important component of health. It represents the capacity of the cardiovascular system and the respiratory system to transport oxygen through the body in order to meet its energy needs (Defina et al., 2015). Effective cardiorespiratory capacity therefore implies the functional integrity of the heart, blood vessels, lungs and muscles. It is associated with the endurance of subject, and corresponds to the ability of large muscle masses to perform dynamic exercise of moderate to vigorous intensity over prolonged periods in the time (Shephard et al., 1968).

According to the description originally proposed by Hill and Upton in 1923, aerobic capacity is expressed as maximum oxygen consumption, also called maximum volume oxygen (VO2max) (Yu et al., 2020). This is actually the maximum value of oxygen consumed by the patient physiologically, despite the increased intensity of exercise. It a so-called plateau phase resulted from which no increase in VO2 was possible (Ferretti, 2014). However, despite reaching maximum effort, this VO2 plateau is not not observable in all individuals (Gordon et al., 2012).

Intensity describes the effort of training in relation to maximum capacity. Relative Intensity is usually represented by a percentage of the heart rate peak (HRmax), peak oxygen consumption (VO2max), or heart rate reserve (HRmax-HRrepos) (Ferguson, 2014).

The intensity of the exercise can also be defined in absolute value by the expenditure of measured energy. It is then expressed according to the metabolic equivalent of the task (or MET from English Metabolic Equivalent Of Task), in kcal / min or by absolute consumption of oxygen per individual (VO2 in L/ min). Light physical activity is 3 MET, moderate from 3 to 6 MET and vigorous from 6 MET (Ferguson, 2014) (Appendix 2*)*.

VO2 can be expressed in absolute terms (ml / min or L / min), or in relative terms taking into consideration the weight of individuals (ml / kg / min or L / kg / min) which makes it possible to compare individuals among themselves (Ferguson, 2014). VO2max depends on sex, age, physical condition of individual and certain genetic factors (Ferretti, 2014). It is possible to assess exercise tolerance of the subject during a stress test (ST), during which a value of the VO2max is calculated.This involves analyzing the ventilation as well as the gas exhaled by the patient (Shephard et al., 1968).

When cardiorespiratory capacity is reduced, it leads to an increased risk of cardiovascular disease and even premature death, while an increase is associated to numerous health benefits (Blair et al., 1996). Children with cerebral palsy have reduced aerobic capacity compared to children with normal development (Balemans et al., 2013).

Due to their lack of physical activity, these children also have a VO2max lower than that of their peers (Balemans et al., 2013). In order to prevent the development of disabilities and the deterioration of the child's quality of life, early treatment is necessary. It therefore seems that the window of prevention of cardiorespiratory complications in people with cerebral palsy, appears before reaching adulthood.

2.2.2. Therapeutical point of view

2.2.2.1.Objectives of Therapy

Regarding cardiorespiratory function, the rehabilitation objectives are as follows (Antonello & Delplanque 2009):

- Develop and maintain lung capacity
- Fight against cardiorespiratory mismatch
- Fight against thoracic and spinal deformities
- Raise the functional level and autonomy of the patient during ADLs
- Prevent the associated cardiovascular risks
- Ensure patient safety

2.2.2.2.Principles of Therapy

Physiotherapy treatment depends on the origin of the disorder which may be related to the external, internal mechanical or usually mixed (Antonello & Delplanque 2009). It must be as comprehensive as possible and focus primarily on the causes (etiological treatment). The two major axes will be: decluttering and maintaining respiratory function (Antonello & Delplanque 2009).

2.2.2.3.Therapeutic responses

In order to improve cardiorespiratory capacity, physiotherapy rehabilitation must take into account the subject's endurance physical activity (Antonello & Delplanque 2009). Physical activity is described by the English American College of Sports Medicine or ACSM as "any bodily movement produced by the contraction of muscles skeletal, resulting in a substantial increase in caloric requirements compared to energy expenditure at rest ”. It therefore differs from the physical capacity which corresponds the ability to perform a physical activity based on a set of attributes specific to the individual (Ferguson, 2014). ACSM issues several recommendations aimed at improving capacity physical. The most recent guidelines are published in 2018 and aim to improve the aerobic capacity in healthy adults. The modalities of practice of the activity are defined there (frequency, intensity, time, type, volume) and the notion of progressivity is also mentioned.

These areas of support defined in the general population must be adapted and take into account the neurological context and cognitive disorders linked to the CP child.

2.2.3. Management approaches in CP children

2.2.3.1.Objectives of approaches

Rehabilitation in physiotherapy for CP children aims to improve the motor functions,and prevention of the development of secondary and tertiary abnormalities.Added to the objectives previously formulated in the general population, this support aims to:

- Prevent deterioration of the cardiorespiratory system
- Bring comfort and reduce pain
- Improve the social integration and participation of the child
- Promote therapeutic education of the child and his parents

All of these objectives aim to lead the young child to the more possible autonomous adult life.

2.2.3.2.Physiotherapy principles

Monitoring of children with cerebral palsy should be early. Rehabilitation must be personalized and take into account the neurological context and cognitive disorders related with cerebral palsy (25). It can only be considered with the support of the child and his parents. This therapeutical process is medical and rehabilitative, and inseparable from educational and social support.A multidisciplinary intervention is therefore recommended.

2.2.3.3.Therapeutic responses

The multiple-disabled subject may be sollicited in terms of his adaptation to the effort during the physiotherapy sessions, depending on their motor skills: sequence of rollovers, squats, or even walking guidance (De La Gastine & Stagnara 2017).

In 2003, the pediatric section of the American Physical therapy Association and its research committee, emphasized the critical need to identify and promote effective interventions, to improve the cardiorespiratory condition in children with CP (Jette & Portney, 2003).

Physical activity is important for the health of young people, both in the general population than in children with multiple disabilities. Over the past two decades, the focus has been on moderate to vigorous exercise when designing activity programs and exercises for children and adolescents with cerebral palsy.

New evidence suggests that sedentary behavior is markedly different from lack of moderate to vigorous physical activity and involves independent physiological mechanisms.The idea of simultaneously increasing moderate to vigorous physical activity and replacing sedentary behavior with light physical activity can be beneficial for children and adolescents with CP (Rogers et al., 2008).

Two systematic reviews investigated the effect of cardiorespiratory training in children with CP (Verschuren et al., 2007), and concluded that this training can improve physiological parameters associated with aerobic capacity. Following the first studies, training programs aimed at improving the aerobic capacity of children and adolescents with CP have grown in popularity.

The most recent recommendations for improving cardiorespiratory capacity, are taken from a review of the literature by Verschueren et al. carried out in 2016, and based on the study of 5 randomized controlled trials (Verschuren et al., 2016). They indicate that the

aerobic exercise 2 to 3 times a week from 60 to 95% of the maximum heart rate, would increase the subject's aerobic capacity. This heart rate range corresponds at the suggested training intensity between 64% and 95% of maximum heart rate qualified as moderate to vigorous training by ACSM (Garber et al., 2011). When the intensity is not defined based on HRmax, exercise should be between 40% to 80% of heart rate reserve or between 50% and 65% of peak of VO2. This program should be continued for at least 8 consecutive weeks three times a week or for 16 consecutive weeks twice a week, in sessions of 20 minutes.

2.2.4. Management issues

2.2.4.1. Sustainable maintenance of aerobic capacity

Although specific to the CP patient, the recommendations for physical activity are not always followed in reality (Verschuren et al., 2016). The expected rhythm and intensity are difficult to respect by this population, and intrinsic and extrinsic barriers may be encountered (Verschuren et al., 2012). The recommendations mentioned above also mention the need to promote and encourage physical activity as part of protocols in clinics and therapy centers for people with cerebral palsy (Verschuren et al., 2016). Acting on the behavioral lifestyle of individuals, such guidelines will help to improve aerobic capacity over the long term. In adolescents, due to the psychological complexities related to age as well as a desire for autonomy, a disinvestment for rehabilitation is frequently observed (Maher et al., 2016). This is a period of transition between abilities and habits developed during childhood, and their evolution into adulthood.

2.2.4.2.Cardiorespiratory capacity and function

Within our research work, the functional capacity of the Cp child concerns the posture and movement ability, grip, communication, as well as the ability to carry out activities of daily living.

The practice of physical activity is frequently recommended by professionals of health care for people with CP, mainly to improve their functional abilities.

Indeed, as mentioned previously, the disorders presented by CP children cause a decrease in their functional abilities. In addition, due to a reduced aerobic capacity, these children have reduced walking endurance limiting their walking perimeter as well as their quality of life (Maltais et al., 2014). Studies have also meant that walking is associated with an energy expenditure 3.3 times higher than in children with normal development, due to the decrease in their aerobic capacity (Rose et al., 1990).

According to a systematic review by Cochrane, it appears that aerobic exercise results in a slight improvement in the overall motor function of the CP child in the short term,although it does not increase walking speed (Garber et al., 2011). However, in view of the low quality of studies, this same review encourages additional high-level research evidence to assess the relationship between physical activity and functional abilities of cerebral palsy population. In addition, nowadays, to our knowledge, there is no research exploring the impact of improving aerobic fitness, on function or subject's quality of life .

2.2.4.3.Physiotherapy interventions

Physiotherapist is a health professional, a specialist focused on rehabilitation. Certain acts, such as orthopedic, respiratory or cardiovascular rehabilitation, are reserved for it. He uses physical and sports activity for this purpose. Nevertheless, the current recommendations for the management of cardiorespiratory disorders in CP children do not describe a specific application by the physiotherapist (Verschuren et al., 2007). The increasing emphasis on physical activity levels, changes in health systems in different countries and an increasingly comorbid and aging society will shape the next steps in the evolution of cardiorespiratory physiotherapy. The physiotherapists must adapt to these evolutions and provide the most effective treatments in improving patient outcomes in all facets of the cardiorespiratory practice (Denehy et al., 2018).

3. Methodology of the study

3.1.Context and problematization

While reading scientific articles, we have seen the importance of development of cardiorespiratory capacity during the rehabilitation of the cerebral palsy patient. Today, the literature encourages the early management of this type of disorder towards reducing sedentary behavior and increasing intensive physical activity in children, with the aim of preventing cardiorespiratory mismatch at the adult age. If the practice of physical activity is also recommended to improve the functional capacities of cerebral palsy, high-level research evidence are encouraged in order to more precisely assess the impact of the activity on the function. The current recommendations define the modalities of application (type, frequency and intensity) of the activity to improve aerobic capacity in CP children.

However, in view of the child's limited capacities, it appears difficult to achieve these recommendations, which seems to hamper the sustainability of the benefits gained from the activity. In addition, their application has not been specifically defined for the practice of the physiotherapist and the intervention of the practitioner in such therapy is not evoked.

It would therefore seem that further research is needed to identify the parameters of physical activity, likely to sustainably improve aerobic capacity of the CP child, as part of the therapy by the physiotherapist.

The following research question was then defined: **Regarding interventions intended to improve the cardiorespiratory capacity of the CP child present in the scientific literature, which elements could be included in the practice of physiotherapist to ensure a lasting improvement of the aerobic capacity in CP children , during physical activity?**

3.1.1. Objectives

Based on current recommendations and programs to improve cardiorespiratory capacity, we want to define the elements involved in the physical activity which will allow the physiotherapist to improve the aerobic capacity of the CP child during therapeutical sessions. We are also looking to identify the parameters helping to maintain these effects over time. Finally, we hope to highlight a relationship between increased aerobic capacity and improved function.

From the research question, two primary objectives are then established:

- Identify the types of physical activity improving the aerobic capacity of the CP child.
- Identify the parameters influencing the sustainable maintenance of aerobic capacity

We also define a secondary objective:

- Highlight the relationship between aerobic capacity and CP child function

3.1.2. Hypothesis

In relation to the problematic, we formulate the following hypothesis:

- The practice of intensive physical activity is today an effective way to improve aerobic capacity in children with CP.
- An intervention acting on the barriers to activity promotes the sustainable maintenance of the aerobic capacity of the child with cerebral Palsy.
- Improved aerobic capacity leads to improved functional capacity for the cerebral Palsy child.

The purpose of carrying out our study will then be to confirm or refute these hypotheses.

3.2.Research strategy

Further research is needed to answer the question previously formulated, which led us to carry out this inventory of the literature. The Databases used were PubMed, PEDRO, SCIENCE DIRECT and COCHRANE LIBRARY.

3.2.1. PICO criteria

In order to carry out our research equations, we used the PICO criteria (De Morton, 2009) (Table 3). This method made it possible to highlight key words and their synonym: These key words are: "children, young", "cerebral palsy", “rehabilitation, intervention, program”, “physical activity, training, exercise”, “cardiorespiratory fitness, aerobic”.

PICO criteria	Information
P = population, patient, Problem	CP child
I = therapeutic intervention	Physical activity program
C = reference treatment or intervention, Placebo, no treatment evaluated	/
O = Clinical outcome, measured event	Aerobic capacity Functional capacity

Table 3. PICO criteria of the research question

3.2.2. Search equations and databases

The search equations were developed using the keywords previously cited and Boolean operators, depending on the search engine used (table 4).

Database	Research equations
Cochrane Library	(cardiorespiratory fitness OR aerobic) AND (physical activity OR exercise OR training) AND (Cerebral palsy) AND (children OR young) AND (Rehabilitation OR program OR intervention)
PubMed	(cardiorespiratory fitness OR aerobic)AND (Cerebral palsy) AND (physical activity OR exercise OR training) AND(children OR young) AND (Rehabilitation OR program OR intervention)
Pedro	Title: cerebral palsy Therapy: fitness training Problem: reduced exercise tolerance
Science direct	(cardiorespiratory fitness OR aerobic) AND (Rehabilitation OR program OR intervention) (Cerebral palsy) AND (children) AND (physical activity OR exercise OR training)

Table 4. Research equations by database

3.2.3. *Inclusion and exclusion criteria*

In order to retain the most relevant publications, inclusion criteria and exclusion studies were established (Table 5). The PICO criteria indicated previously, helped to formulate items about population, intervention, and measurement. We have also excluded the languages that we do not understand. Then, considering the low number of studies with a high level of evidence, we have chosen to include the trials randomized controlled and controlled trials. Finally, we have decided to exclude publications older than 10 years to avoid a possible discrepancy between current practices and old publications.

ITEM	INCLUSION CRITERIA	EXCLUSION CRITERIA
Language	French and English	Languages other than French or English
Date of publication	10 Years maximum	Publications older than 10 years
Type of study	-Randomized controlled study - Controlled study	Guidelines, Chapter or book excerpts
Population	-CP -Age < 21 years old -GMFCS I to V	-Pathologies excluding cerebral palsy -Adults
Intervention	-Physical activity -Training program	-Diagnostic -Treatment other than physical activity
Evaluation	-Results on aerobic capacity -Results on keeping it on distance from intervention -Results on the function	Results not including aerobic capacity

Table 5. study inclusion and exclusion criteria

3.3.Documentary research process

From the research equations emitted we questioned the different databases. This allowed us to obtain N = 282 results. After this step, we have removed the duplicates (N = 20) to end up with a final total of 262 articles.

Then, after reading the title and the abstract, we have removed the articles which do not coincide with the inclusion and exclusion criteria formulated. N = 11 articles were retained at the end of this selection. On full reading, we excluded articles that did not agree with our criteria. In total, N = 5 articles were considered eligible.

Data bases	Number of items found
PEDRO	21
COCHRANE LIBRARY	22
SCIENCE DIRECT	54
PUBMED	185
TOTAL WITH DUPLICATES	282
TOTAL WITHOUT DUPLICATES	262

Table 6. results of the documentary research

At the end of this documentary research, we therefore obtained 2 randomized controlled trials, and three non-randomized controlled trials. The heterogeneity of the literature will be taken into consideration when critically analyzing references.

3.4.Critical analysis of references

3.4.1. Analysis of randomized controlled studies

To begin the critical analysis of this work, we used the Pedro scale (Maher et al., 2003) *(Fig. 4- Annex 3)* . This scale is made up of 11 criteria aimed at assessing the methodological quality of randomized controlled studies. The criteria from 2 to 9 allow assess the internal validity of the study, while criteria 10 to 11 indicate whether the statistical information is used to interpret the results of this study. Item 1, relating to the external validity and "generalization" of the results, is not taken into account in the final score. A score lower than 4 indicates a low level of evidence, a score between 4 and 6 of a moderate level, and a score between 6 and 10 reflects a high level of methodological quality. On the other hand, the score obtained does not allow a conclusion as to the significance and usefulness of a treatment.

AUTHORS	ITEMS											TOTAL
	1	2	3	4	5	6	7	8	9	10	11	
Van Wely et al. (56)	x	x	x	x		x	x	x		x	x	8/10
Cleary et al. (57)	x	x	x	x				x	x	x	x	7/10

Table 7. Evaluation of internal validity with the Pedro scale

In order to continue to assess the relevance of these studies, we seek to estimate the power. Indeed, the articles of this literature review are based only on a sample of the population. The larger is the sample, the more power increases the chances that it is representative of the population. A workforce is considered low if it is less than 30. We have therefore listed the numbers of each study in order to calculate the average.

Authors	**Sample size**
Van Wely et al.2014	49
Cleary et al.2017	19
Effective average	34

Table 8. study sample size

We calculate an average of 34, our sample of study of randomized controlled trials is therefore not considered low. At the end of the critical analysis of the randomized controlled trials, we therefore chose to keep these two references.

3.4.2. Analysis of non-randomized controlled studies

The modified Newcastle – Ottawa scale is a tool for assessing the quality of non-randomized controlled studies (in particular case-control and cohort studies) (Luchini et al., 2017) *(Fig. 5- Annex 3)*. It includes 8 items composed of 3 subscales, the maximum score of which is of 10: 4 points relate to the quality of the selection of study groups, 2 points are intended for comparability between cases and controls, and the last 4 points assess the relevance of the results. In this scale, the score is expressed by stars. Any specific value is not assigned to define the quality level of the study, although a score higher reflects good methodology.

Among the non-randomized controlled trials, we find two cohort studies. The modified scale from Newcastle-Ottawa, suitable for this type of study, is then used. On the other hand, one of the publications is a study not involving comparison with a control group, but only at the values measured at the start of the experiment. Since to our knowledge, there is no specific scale for the evaluation of this type of study, the analysis is also performed using the modified Newcastle-Ottawa scale.

This will also make it easier to compare different works. In view of the obtained scores, we have decided to include these publications in our review. Objectified biases will be taken into consideration in the rest of this work.

Studies	Selection				Comparability	Exposure			Score
	1	2	3	4	5	6	7	8	
Zwinkels et al. (59)	*	*	*	*	*	*	*	*	7/10
Nsenga et al. (60)	*	*	*	*	*	*	*	*	7/10
Lauglo et al. (61)			**	*		*			4/10

Table 9. Evaluation of internal validity with the Newcastle-Ottawa scale

The different stages of the documentary research leading to the inclusion of these five references are represented using a flow diagram below (Fig. 5)

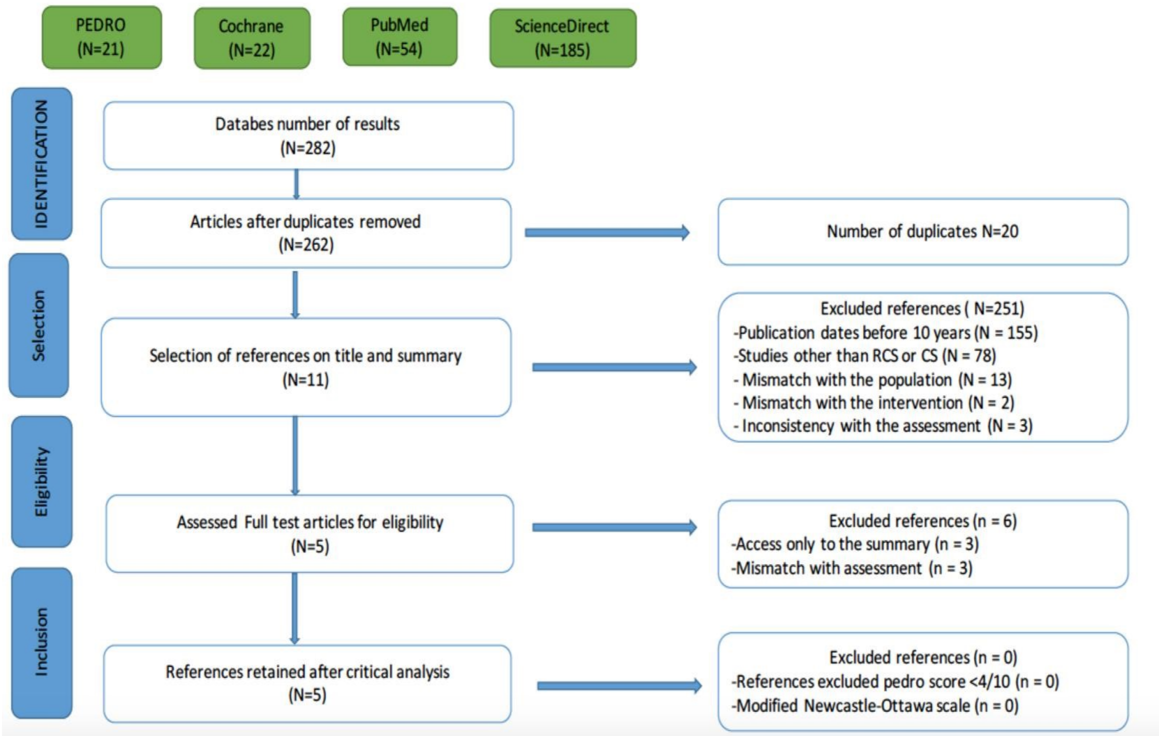

Figure 3. Literature Search Flowchart

4. Study results

4.1. General characteristics

To follow up on the selection of these five studies, we will carry out the synthesis of various presentations and the results of these publications. Only the parameters concerning aerobic capacity and maintenance of the effects of the intervention in the long term will be considered in this work.

The other results obtained will not be detailed. The table summarizing the general characteristics of the studies is presented in (*Table 10*).

We describe the interventions as well as the results obtained for each of the five studies.The publications are presented in ascending order of level of scientific evidence *(Table11 , 12).*

4.1.1. Summary of the different interventions

The study by Van Wely et al. (Van Wely et al., 2014), presents a program to stimulate physical activity carried out with CP children for six months. Forty-nine children aged 7 to 13 and GMFCS levels I to III, are randomly assigned to a control group and a group intervention. In the control group, 24 participants received only the usual physiotherapy in pediatric practice.

During these six months, a motivational lifestyle intervention aims to bring about a change in behavior towards physical activity. Advices using the motivational interview technique are provided to parents and children at home. During the same period, home physiotherapy sessions promoting activity in ecological situations are carried out by the usual physiotherapist, with the aim to increase the capacity for daily activities. In parallel, during the first four month of the intervention, a physical reconditioning program is established from existing protocols to improve muscle strength and anaerobic capacity in CP children. Children are trained in groups of two to five under the supervision of their physiotherapist. Initially, training takes place twice a week for a period of hour, then from the second month, the weekly frequency decreases to once per week. Each session begins with a warm-up, then it is continued by two muscle strengthening exercises for the lower limbs, and three playful anaerobic training exercices (running, slaloms). The session then ends with a moment of return to calm and relaxation. The training load is progressive throughout this physical reconditioning program.

Interventions between the different groups are standardized since the physiotherapists follow the same initial training and indicate for each session the training methods (load, number of sets, repetitions).

In the study by (Cleary et al., 2017), the physical activity program takes place within a specialized school. This intervention is designed and supervised by a physiotherapist. At prerequisite, personalized activity programs are developed by students in final year of physiotherapy, asking children about their preferences and Goals. Nineteen children aged between 8 and 18 and GMFCS I to III levels, are distributed randomly between an intervention group and a control group. The group intervention is divided into sub-groups varying from three to four participants, with a ratio of supervision of 1 to 1 or 1 to 2. For nine weeks, the intervention group participate in an aerobic exercise program during lunch break. The intervention lasts thirty minutes, and takes place three times a week.A time to have lunch and rest before the activity is scheduled. During the school term, the control group participates in a artistic and social program. The physical activity program is designed according to the ACSM guidelines in 2006. Students begin the session with a ten minutes warm-up on a treadmill, stationary bicycle,stepping machine, or an arm ergometer. Then, depending on the weather and children's preferences, group and outdoor activities are favored (games of basketball, football, speed, brisk walking ...). Participants within the same group can access different activities according to their preferences.

Supervisors failing on initial measurement, a maximum heart rate of 194 beats per minute is therefore estimated for each of the participants using the calculation proposed by Verschuren et al. A target heart rate, measured by students using monitors, is set: between 60 and 70% of the maximum heart rate (HR max) during the first seven weeks, then between 70% and 80% of max HR during the last two weeks of intervention. When the target heart rate is not reached, the child changes activity.

In the study by Nsenga et al. (Nsenga et al., 2013), 10 CP children from a specialized school underwent an 8 week intervention. Ten children recruited from standard secondary school (group AB), and ten other CP children (CP group) serve as the control group and participate in the their college's regular physical education program. The initial cardiorespiratory test and cyclo-ergometer training is supervised by a certified physiotherapist. The sessions take place three times a week, at the same time. Before each training, children do lower limb and upper limb stretches, as well as breathing exercises supervised by a physiotherapist. The training begins then by five minutes of warm-up (pedaling at 50 laps and a power of 30 Watts), then the children continue with a thirty minute exercise at 50% of the VO2max during the first two weeks. This percentage is increased to 55% during the third and fourth week, 60% in the fifth and sixth weeks and 65% in the seventh and eighth week, still based on the ratio of carbon dioxide (CO2) rate.

Each workout ends with five minutes of passive recovery. The subjects receive verbal encouragement during the session. A cardiorespiratory test is carried out again at the end of the eight weeks of training in order to assess the VO2max of subjects.

The study by (Zwinkels et al., 2018) presents a physical activity program in schools. The study included 71 young people aged 8 to 18, including 27 CP children whose GMFCS level was not precised. For 8 weeks, all participants perform high-level exercises intensity twice a week. At the end of this initial training intended to familiarize the children to physical activity, the school-based program begins. The sport group (n = 31) participates in a school sports program once a week for six months, which included team sports. The control group (n = 40) followed the regular program . Each week, for 45 minutes, a physical educator intervenes in addition to the program of regular physical activity. The exercise is provided by an experienced and motivated physical educator.He adapts the activity to the cognitive level and skills of the children. Yes no instruction on intensity is specified, children are encouraged to move, play and have fun in groups during activities such as: football, basketball or hockey.

Outcome measures were assessed at baseline (T0), after 8 weeks of exercise at high intensity (T1) and at the end of the intervention (T2).

The study by (Lauglo et al., 2016) presents a high intensity interval training program carried out with children aged 10 to 17 and GMFCS levels I to IV, supervised by a physiotherapist. This is a study using baseline values as a control.Aerobic fitness tests are performed at three different times: upon study registration (T0), after a period of usual activity of four weeks (T1) and at the end of the program (T2). The metabolic composition is measured at T1 and T2. Exercise sessions are performed two to four times per week, up to a maximum of twenty-four sessions.The session begins with a five to ten minute warm-up performed at a low intensity to moderate. The intervention consists of performing four sets of exercise on a mat (walking or running) so as to reach at least 85% of HRmax. The study including children of level GMFCS IV, four study participants use a partial weight support system of the body (FreeSpann with Likorall 200 and vest) during physical training . The protocol is individualized so that all participants complete sets of one to four minutes of high intensity exercise for sixteen minutes. Active rest phases carried out at 70% of HRmax are performed between each set and at the end of the exercise. If the duration of high intensity exercise decreases, the duration of the rest phase is also shorter.

4.1.2. Summary of results concerning aerobic capacity

In the study by (Van Wely et al., 2014), aerobic capacity is assessed during an exercise test progressive continuous on a cyclo-ergometer in order to determine the VO2max by measuring the pulmonary gas exchange with the Quark CPET system. The maximum output power (W) is defined as the highest gas output during the test. The study does not relate no significant difference in aerobic capacity when assessed at 4, 6 and 12 months. However, we do not have access to quantitative data in tabular form.

In the study by (Cleary et al., 2017), a measurement of the evolution of aerobic capacity is carried out using a 6-minute walk test and during a submaximal treadmill test.These measurements are taken at the start of the study (T0), at the end of the intervention during the tenth week (T10), and also in the twentieth week at a distance from program (T20). At T10, a significant improvement in aerobic capacity in favor of intervention group is observed during submaximal treadmill stress test ($p < 0.05$).

The size of the intervention effect is moderate ($d = 0.7$). However, these effects are not maintained during the evaluation at T20. A tendency to improve aerobic capacity ($p > 0.05$) in favor of the intervention group is also observed during the walk test 6 minutes at T20, with an average effect size ($d = 0.5$).

In the study by (Nsenga et al., 2013), gas exchanges are checked during the cardiorespiratory test on a cyclo-ergometer using a Cosmed K4b device. Every 15 seconds, an operator measures the O2 input, the VO2 and CO2 flows, the equivalent ventilation for O2 (EV/VO 2) and CO2 (EV/ VCO2), as well as respiratory rate.The test ends when the subject is stopped by fatigue, dyspnea, or inability to maintain the required rhythm . Heart rate is monitored every minute by thoracic electrodes connected to the Cosmed system. One week after this initial cardiorespiratory test, subjects begin the training program. Then at the end of the study, the children again perform a cardiorespiratory test. Before training, there were no significant differences between groups with CP and with children subjected to a physical exercise, but the maximum aerobic power of the two groups differed about 18% compared to the figures observed in the group of people without disabilities. In addition, control groups AB and CP showed no significant statistically change compared to the initial values. However, after the aerobic training program, a significant increase in VO2max ($p < 0.05$), HR, and maximum EV is seen in subjects with CP. The value of VO2max thus increases from 35.6 ± 5.6 mL / kg / min to 43.4 ± 4.7 mL / kg / min.

In the study by (Zwinkels et al., 2018), aerobic capacity is measured during the 10m test of the shuttles. The VO2 peak is measured and the number of shuttles obtained defines the performance.

This progressive exercise test is performed while walking, running, or in a wheelchair until exhaustion. A calibrated Cortex Metamax 3X mixing chamber (Samcon bvba,Melle, Belgium) was used to measure the peak VO2. During this ordeal, a metabolic stress test software (Metasoft Studio) was used to measure absorption oxygen (VO2), production of carbon dioxide (VCO2), peak of heart rate (HR) and the respiratory exchange ratio $(RER) = (VCO2 / VO2)$.

The determining signs of attainment of VO2max by the subjects are as follows: HR ≥ 180bpm, RER ≥1.00 at moment of exertion, or subjective signs of intense exertion (sweating, redness etc…). At the end of this study, the intervention group shows no significant improvement for aerobic performance and VO2max.

In the study by (Lauglo et al., 2016), the main judgment criteria of the research are the VO2max and the cost of oxygen during submaximal effort (VO2submax). These measures are performed at times T0, T1 and T2 of the study, during a maximum stress test on a treadmill with direct measurements of oxygen consumption. Heart rate is also monitored throughout the test. The maximum stress test is carried out on a treadmill with increasing load until the subject's subjective exhaustion. VO2peak is reached when the respiratory exchange rate at the end of the test is ≥1.05 and the Borg scale score is ≥17. Only participants achieving VO2max are included in the VO2max analyzes. The submaximal effort test is made at a constant rate on the treadmill for 4 minutes. Oxygen absorption and heart rate are measured. In addition the average of the last minute is used to estimate the submaximal heart rate and VO2submax. The fractional oxygen cost of the submaximal effort is then calculated as than percentage of VO2max. According to this study, VO2max significantly increases by 10% after intensive exercise program (between T1 and T2), from 37.3 (31.0–40.1) mL / kg / min to 41.0 (36.6–48.5) mL / kg / min ($p < 0.01$). The submaximal stress test does not allow the observation of a significant difference in the VO2smax between time points ($p = 0.12$). In contrast, a significant difference in submaximal heart rate is observed ($p = 0.03$), with a decrease of 10 beats per minute between T1 and T2. The percentage of use of VO2max during the submaximal stress test decreases therefore significantly between T1 and T2.

4.1.3. Summary of results concerning the maintenance of aerobic capacity

In the study by (Van Wely et al., 2014), a remote measurement of this stimulation program of the activity is carried out six months after the end of the intervention. However, no significant improvement is recognized at this date, nor during previous evaluations.

The intervention presented by (Cleary et al., 2017) extends over a period of 9 weeks. Measurements Of aerobic capacity are nevertheless carried out at T10, that means one week after the end of the program, and also at T20 eleven weeks after the intervention. If the effects measured by the submaximal stress test on a treadmill are not maintained at T20, the 6-minute walk test reflects a durability of improved aerobic capacity up to T20. This ambivalence will have to be discussed.

In the studies by (Lauglo et al., 2016), (Nsenga et al., 2013), as well as (Zwinkels et al., 2018), no measurement of aerobic capacity is carried out at a distance from the procedure. So we don't have any information on a possible lasting effect of the intervention on this result.

4.1.4. Results concerning the function

The study by (Van Wely et al., 2014), observe the effect of the stimulation program of the the Physical activity on the mobility capacity including: the motor capacity, the walking capacity, and the Muscular force. The results are evaluated at the starting of the intervention, at 4 months, at 6 months (at the end of the operation), then at 12 months. Walking ability is measured during the 1 minute walk, and motor ability is assessed by the GMFM-66.

The study does not reveal any significant difference in mobility capacity at 4 months, 6 months or 12 months. However, a positive trend is observed for motor ability at 6 months.(mean difference between groups 2.8, 95% CI 0.2 to 5.4), but not at 12 months. It is same for walking ability at 4 months (mean difference between groups 5 m, CI at 95% from 0 to 9), but not at 6 months or 12 months.

In the study by (Cleary et al., 2017), as specified previously, the secondary results such as quality of life, are measured at T0, T10 and T20 by a "blind" rater .

The health-related quality of life is assessed using a "questionnaire on the quality of life for children with cerebral palsy " (CP QOLChild). This questionnaire is completed by 13 parents among the 19 participants. The estimation of the effect is large,favoring the control group for the functional domain ($d = -1.1$). This effect is not maintained at week 20. On the other hand, the intervention seems to significantly reduce the pain, and we see an average effect in the assessment at week 10 ($d = 0.7$). This effect is not maintained during the evaluation at week 20. No significant difference within or between groups is observed at week 10 or week 20. This questionnaire is also completed by 7 children, and no significant difference is observed between weeks 10 and 20.

The study by (Lauglo et al., 2016) assesses the health-related quality of life of participants using the KINDL10 questionnaire. This measurement is carried out at times T0, T1 and T2. It includes 24 items divided into six subscales, each item addressing the experiences of child during the past week. Adults and children each complete this same questionnaire. Questionnaire reported by parents reveals a significant difference in the total score ($p = 0.04$), as well as in the self-esteem subscale ($p = 0.02$) throughout the study. The difference between T1 and T2 is also significant ($p = 0.01$). On the other hand, no significant change is noticed for the quality of life declared by children.

In the studies by (Nsenga et al., 2013) and (Zwinkels et al., 2018), the functional impact of intervention according to the criteria defined in our conceptual framework is not evaluated.

	Population	Interventions	Location	Duration (In Weeks)	Therapy Modalities	Supervisor
Van Wely Et Al. 2014	N = 49 Age 7-13 years GMFCS I-III	Physical activity Physiotherapy at home Motivational interview Advice	Home Physiothe ra-pist office	24	**Type :** Strenthening, Anaerobic games **Duration :** 1 hour **Intensity :** / **Frequency :** 1-2x / week	physiotherapist
Cleary Et Al. 2017	N= 19 Age 8-18 years old GMFCS I-III	Aerobic exercise in school specialized	Education al establish me-nt	9	**Type :** Aerobic on Cycloergometer, mat, outdoor activities, team sports **Duration :** 30 min **Intensity :** 60-80% HRmax **Frequency :** 3x / week	physiotherapist
Nsenga Et Al. 2013	N = 30 Age 10-16 years GFMCS I-II	Physical activity Respiratory physiotherapy Stretching	Education al establish ment	8	**Type :** Aerobic on Cycloergometer **Duration :** 30 min **Intensity :** 50-65% VO2max **Frequency :** 3x / week	physiotherapist
Zwinkels Et Al. 2018	N= 71 Age 8-18 years old GMFCS unknown	Physical activity	Education al establish ment	24	**Type :** Games, team sports **Duration :** 45 min **Intensity :** / **Frequency :** 1x / week	Specialized physical Educator
Lauglo Et Al. 2016	N= 20 Age 10-17 years old GMFCS I-IV	Physical activity	Not indicated	5-14	**Type :** HIT on carpet **Duration :** 20 min **Intensity :**> 85% HRmax Frequency : 2-4 x / week	physiotherapist

Table 10. Summary of the general characteristics of the studies

	Assessment Tool	Results
Van Wely et al. 2014	Progressive test on a cycloergometer	• 6 months: Ø • 12 months: Ø
Cleary et al. 2017	6 minute walk test Submaximal Treadmill Test	6 minute walk test • T0-T10: Ø • T0-T20: increase (d = 0.05) Submaximal Treadmill test • T0-T10: increase (MD = 0.9) • T10-T20: Ø
Nsenga et al. 2013	Progressive test on cycloergometer	• Week 8: Increase (p <0.05)
Zwenga et al. 2018	Shuttle test	• Ø
Lauglo et al. 2016	Maximum stress test on treadmill	• T0-T1: Ø • T1-T2: increase VO2max (p<0.01)

Table 11. Summary of results concerning aerobic capacity

	Evaluated Function	Assessment Tool	Results
Van Wely et al. 2014	Walking ability Motor capacity	1 minute walk test, GMFM-66	Walking ability • 6 months: Ø • 12 months: Ø Motor capacity • 6 months: increase • 12 months: Ø
Cleary et al. 2017	Quality of life Pain	QOLChild CP Questionnaire	Children • T0-T10: Ø • T0-T20: Ø Parents • T0-T10: pain reduction (d = 0.7) • T10-T20: Ø
Nsenga et al. 2013	/	/	/
Zwenga et al. 2018	/	/	/
Lauglo et al. 2016	Quality of life	Questionnaire KINDL10	Children • T0-T1: Ø • T1-T2: Ø Parents • T0-T1: improvement (p <0.04) • T1-T2: improvement (p <0.01)

Table 12. Summary of the results concerning the function

5. Discussion

5.1. Interpretation of results

During the contextualization of the study, three hypotheses related to our problematic have been formulated. At the end of this literature review, we note the emergence of four main axes : the parameters intervening in the improvement of the cardiorespiratory capacity, the elements likely to maintain the improvement of the aerobic in distance from the intervention, the measurement tools used to evaluate it, and finally its impact on the function of the CP child. In this discussion we will therefore start by interpreting these results, which will allow us to deduce or not the validation of the assumptions made beforehand.

5.1.1. Improvement of cardiorespiratory capacity

5.1.1.1.Definition of objectives

Among the five interventions analyzed, four involve the supervision of a physiotherapist or physiotherapy students. In addition, the study by Cleary et al. is not only carried out but also designed by a physiotherapist (Cleary et al., 2017). This confirms the relevance of the practice of physical activity by the physiotherapist when taking charge of Cardiorespiratory disorders in the young patient with cerebral palsy. In Zwinkels' study et al., the action is carried out by a specialized physical educator (Zwinkels et al., 2018).

In the four studies carried out by physiotherapists, the practitioner first defines goals to be achieved by the child. This may be a target heart rate (Van Wely et al., 2014) (Cleary et al., 2017) (Lauglo et al. 2016), or a certain percentage of the VO2max (Nsenga et al., 2013). Conversely, in the exploration of Zwinkels et al., The physical activity educator responsible for the action, gives no instruction on the intensity of the exercise to be performed (Zwinkels et al., 2018). Children are encouraged to be active and have fun in activities such as wheelchair basketball, soccer, hockey, or simple ball games. However, no significant improvement in the capacity aerobic was observed at the end of this study.

If the establishment of a target intensity to be reached is not a real objective of rehabilitation in terms of intake for the child, it is necessary for improving aerobic capacity. The therapy must therefore be directed towards a goal. Indeed, according to multiple publications, the care of the CP child directed towards measurable and specific objectives significantly increase the latter's performance (Bower et al., 1996) (Krasny-Pacini et al., 2013). The recommendations concerning the formulation of rehabilitation objectives indicate that they should respect the SMART principle, an abbreviation derived from the American and which means: "Specific, Measurable, Acceptable, Realistic and Temporarily defined". The SMART principle makes it possible to describe objectives in a way that is clear and accessible to everyone's understanding (Bovend'eerdt et al., 2009). He drives to the development of a common project accepted by all stakeholders from the start.

Establishing such goals also involves parental involvement. Indeed, the triangular relationship that exists between the therapist, the child and the parents leads to three-dimensional rehabilitation stakes (Guilbaud et al., 2018). It seems relevant to ask the child and his family about their goals and knowledge. Working with families must be built on a symmetrical relationship (Guilbaud et al., 2018). The practitioner should ensure that parents understand the best interests of rehabilitation as well as their role as escorts of the child in his project. It is to find the balance between the interests of the child, and the expectations expressed by the parents. This approach then allows the emergence of the same common thread for all, thus than setting meaningful and achievable self-directed goals (Bovend'eerdt et al., 2009).

Nowadays, the scale of goal achievement "Goals Attainment Scale" or GAS is used with CP children (Bovend'eerdt et al., 2009). It is recognized as having good reliability and good sensitivity to clinical significant changes (Steenbeek et al., 2010). In practice, goals may be built according to four main axes: the target activity, the necessary assistance, the quantification performance and the time required for completion. This method is suitable, simple of use and applies to most situations. However, a scale specifying each level of achievement of objectives remains difficult to describe (Krasny-Pacini et al., 2013). Regular assessment of their impairment makes it possible to monitor the progress of the Rehabilitation.

Likewise, the "Canadian Occupational Performance Measure" (COPM) model is suitable for child and measures individual results in pediatric rehabilitation (Tam et al., 2008). It is based on a semi-structured interview focused on the patient's goals and priorities, as well as those of their family. Three objectives related to sports (at least one activity and one activity focused on participation) will be identified by the caregivers. The performance rating scale of their children and their satisfaction with these performances will be calculated on an ordinal scale of 1 to 10. The COPM has high intra-operator reliability (ICC 0.76–0.89). It demonstrates concurrent validity with the measure of functional independence, and it has good sensitivity to change (Donnelly & Carswell, 2002).

5.1.1.2.Types of intervention

All the publications studied present retraining programs intended to improve the cardiorespiratory capacity of children and adolescents with cerebral palsy.

All the studies in this literature review are based in particular on the practice of physical activity with this population.

The programs encountered vary from 8 weeks to 6 months. Now both interventions carried out over a period of 6 months are the only ones not to have involved any significant improvement in the subject's aerobic capacity (Van Wely et al., 2014) (Zwinkels et al., 2018). In view of these results, It would therefore seem that the duration of the program is not a sufficient parameter for improve cardiorespiratory capacity in children.

The components of retraining programs vary from one study to another. Thus, three publications present interventions based only on physical activity program (Cleary et al., 2017) (Zwinkels et al., 2018) (Lauglo et al., 2016), while studies by Nsenga et al. And Van Wely et al. Describe multi-component interventions. Indeed, Nsenga et al. Explore the effectiveness of respiratory physiotherapy associated with stretching before practicing physical activity. When carried out in a dynamic-active way, the stretching seems indicated in order to prepare the musculoskeletal system for the effort, and prevent the risk of injury. This activation of muscle tone is preferentially performed standing, as close as possible to the effort situation (Gedda, 2015) (Delvaux et al., 2017). The study by Van Wely et al., it acts by motivational interviewing and the administration of advice, physiotherapy at home, as well as an anaerobic physical activity program and muscle building. However, this latest study shows no significant improvement of cardiorespiratory capacity, nor any change in the behavior of children facing activity. These results are surprising since they contradict a literature review of 2016 exploring the different types of intervention and their effectiveness with children in wheelchairs (including CP children) (D O'brien et al., 2016). Indeed, this review highlighted the evidence of the effectiveness of "complex" interventions for improving physical capacity, including cardiorespiratory capacity. These so-called "complex" programs included a combination of exercises, or lifestyle interventions, including individual interviews.

In addition, various reviews demonstrate the benefits of multi-component interventions in improving aerobic capacity. Likewise, a randomized controlled study in multiple components (physical activity, motivational interviewing and counseling), had demonstrated significant improvement in aerobic capacity in adolescents and young CP adults aged 16-24 (Slaman et al., 2014).

Nevertheless, the type of physical activity applied was not the same as in the study by (Van Wely et al. 2014), we can imagine that this latter can intervene in the improvement of aerobic capacity. In addition, this study was not applied to a population of children. To our knowledge no study has established an optimal duration for this type of program, we can question ourselves as for less receptivity on the part of children during a six-month intervention. The degree of severity of the pathology, and the modality and type of exercise are also elements to be considered.

Our literature review also includes three studies based only on the establishment of a physical activity program (Cleary et al., 2017) (Zwinkels et al., 2018) (Lauglo et al., 2016). Although the conditions of achievement differs between each of these publications, all note a significant improvement of the aerobic capacity at the end of the intervention. Nowadays, several studies confirm the possibility of improving cardiorespiratory capacity through a physical activity program, in addition to usual care (Antonello & Delplanque, 2009).

5.1.1.3. Modalities of physical activity

Type of activity

ACSM's recommendations for improving cardiorespiratory capacity in healthy adults recommend regular exercises with a defined goal (Rogers et al., 2008). It is also preferable that the activity carried out involves all muscle groups, and be carried out at a continuous rythm. In our study, exercises include walking or running on a treadmill, the cycloergometer with arms or legs, but also teams games and outdoor activities.

Intensity of the activity

In the studies in our review, intensity is described as a percentage of HRmax or VO2max. While the publication by Zwinkels et al. does not establish an instruction as to the intensity of physical activity (Zwinkels et al., 2018), the other publications define a target value to be reached. The workload increased gradually throughout the program, except in the study by (Lauglo et al., 2016). In this study, a target heart rate representing 85% of HRmax was expected to be achieved by children with CP. Van's wely et al. Publication involves a muscle building program described as completed at an increasing intensity, without further precision (Van Wely et al., 2014). The work of Cleary et al. presented an achieved activity between 60 and 70% of HRmax during the first seven weeks, then between 70 and 80% of HRmax during the last two weeks (Cleary et al., 2017). Likewise, in the study of Nsenga et al., Children were expected to reach 50% of their VO2max within the first two weeks (Nsenga et al., 2013). The load then increased by 5% every two weeks, up to reach 65% of their VO2max. All of these intensity values respect the recommendations defined by the ASCM in 2011 for healthy adults (Rogers et al., 2008). They follow also the current guidelines for the cerebral palsy, which recommend an exercise with intensity between 60% and 95% of HRmax, 50% to 65% of VO2max, or still 40-80% of reserve heart rate (Jett & Portney, 2003). We therefore notice that the two studies from our literature review that did not follow intensity guidelines activity, are also those that have not led to any tendency to improve aerobic capacity.

Frequency and duration of the activity

Regarding the number of exercise sessions per week and their duration, we distinguish two categories: a frequency once or twice a week for 45 minutes to 1 hour (Van Wely et al., 2014) (Zwinkels et al., 2018), and a frequency of 2 to 4 times per week between 20 and 30 minutes (Cleary et al., 2017) (Nsenga et al., 2013) (Lauglo et al., 2016). Both initial studies do not allow to conclude as to an improvement of the cardiorespiratory capacity of the CP child. On the other hand, the last three show a significant increase in aerobic capacity at the end of the intervention. These results seem to confirm the current data in the literature according to which training sessions varying from 2 to 4 times per week are recommended for at less than 8 weeks for optimal improvement in aerobic capacity (Jette & Portney, 2003). In addition, according to ACSM guidelines for the general population a practice of 3 to 5 times per week would be necessary (Rogers et al., 2008). However, several studies not following these data have shown an improved aerobic capacity (Verschuren et al., 2008). This last observation is not in agreement with our results since the studies by Zwinkels et al. and Van Wely et al. do not fall under any significant improvement in cardiorespiratory capacity (Van Wely et al., 2014) (Zwinkels et al., 2018). However, the children participating in these last two studies were able to walk (GMFCS level I and II), they therefore exhibited less deconditioning. We can therefore assume that when children with CP are very deconditioned, it is best to start by sessions of 1 to 2 times per week, then gradually increase this frequency.

The durations of the exercises proposed by all the studies comply with the guidelines of ASCM and Verschueren et al. that an activity of at least 20 minutes is recommended (Jette & Portney, 2003) (Rogers et al., 2008).

The recommendations of Verschueren et al. also advise a progression of duration, frequency and intensity of exercise in order to promote adherence and reduce risk of injury associated with activity (Jette & Portney, 2003)

Warm-up and recovery

The publication by Zwinkels et al. is the only study in our review presenting a practice of a physical activity that did not include any warm-up before (Zwinkels et al., 2018). All other studies involve a warm-up phase of 5 to 10 minutes. The publication by Van Wely et al. does not specify how to perform the warm-up (Van Wely et al., 2014). On the other hand, in the exploration of Lauglo et al., this consists of low to moderate intensity exercise, performed on a treadmill (Lauglo et al., 2016). In the study by Nsenga et al., Children achieve a warm-up on a cycloergometer by pedaling at 50 turns per minute and at a power of 30 Watts (Nsenga et al., 2013). According to the literature, active warm-up prior to an exercise such as aerobic significantly reduce the appearance of muscle pain and injury (Goossens et al., 2019). This result would be amplified when a recovery phase is carried out immediately at the end of the warm-up, and at the end of the exercise. A literature review of Bishop also suggests an improvement in performance following a warm-up of low intensity, but a potential deterioration after a warm-up of higher intensity corresponding to 70% of the VO2max (Zois et al., 2015). Regarding passive warm-up, it seems that it does not lead to an improvement in performance or even a deterioration beyond 5 minutes of exercise (Zois et al., 2015).

Organization

Within our study, we notice that two publications describe the division of intervention group during the practice of physical activity. Sub-groups of 2 to 5 children are thus constituted. While it is not specified in the publication by Van Wely et al., The supervision ratio in the study by Cleary et al. is 1 for 1 or 1 for 2. From the latter exploration including final year physiotherapy students, we can imagine that such a supervision ratio is not always applicable in a real clinical situation. As noted previously, this last intervention has been shown to be effective in terms of improving the cardiorespiratory capacity of participants at the end of the program. At seen from the literature, this choice to practice physical activity in subgroups appears relevant. In fact, among the studies that questioned children with CP about the factors facilitating or limiting access to physical activity, practice in a small group supervised by an accessible and communicating practitioner is a facilitating element mentioned recurrently (Shields & Synnot, 2016). Practicing in a small group would allow to acquire the necessary attention for the development of their competence, as well as individualized protocol (Verschuren et al., 2016). This more intimate social environment facilitates the integration of the child into within a group, as well as communication with peers. Conversely, as we note in the study by Zwinkels et al., it appears more difficult to adapt a session training including 31 children when supervised by a single practitioner (Zwinkels et al., 2018). In order to meet the needs of the child and remove environmental barriers to the practice of the activity, interventions at home or within the school appear to be ideal alternatives. Nevertheless, the school has the advantage of favoring interactions in an environment adapted to the child's development. Furthermore, the school provides a framework and a regularity of the practice of exercise.

5.1.2. Assessment of aerobic capacity

This literature review allowed us to observe the use of different tools and aerobic capacity rating scales. The performance of these tests aims to measure various cardiorespiratory parameters, and in particular the VO2max which is considered to be the best physiological marker of aerobic capacity. However, despite careful scientific growth in recent years, aerobic capacity is not systematically evaluated in clinical practice (Balemans et al., 2013).

Nowadays, the baseline assessment in CP children is carried out during a maximum stress test on treadmill (Balemans et al., 2013). However, this test requires the child to have a balance enough to be able to walk and run in the later stages of a treadmill test. This assessment is therefore rarely performed. Nevertheless, the intervention of Lauglo et al., precisely uses this maximal stress test on the carpet to evaluate the VO2max (Zois et al., 2015). It is therefore the gold standard for measuring aerobic capacity, adapted to the capacities of the CP child. Indeed, the publication including non-ambulatory children (GMFCS level III-IV), a system of partial body weight support is used to help them maintain a vertical posture on the mat. This study shows that it is possible to perform an exercise on a walking mat with children of GMFCS III and IV level in complete safety. However, the VO2max was not reached by this population, it is difficult to conclude as to a real effectiveness of evaluation with children of GMFCS III and IV levels. The results concerning the significant improvement in cardiorespiratory capacity are therefore to be weighed since they do not concern the entire population studied at the outset, but only children of GNMFCS I and II levels.

When the application of the gold standard is impossible, the shuttle test carried out over 10m, presented in the study by Zwinkels et al., has good reliability and good validity regarding the measurement of aerobic capacity in young CP (Verschuren et al., 2006). It demonstrates advantages compared to treadmill testing for CP children able to walk or run (GMFCS level I or II) since it can be used in a clinical environment with less equipment available (Balemans et al., 2013). Likewise, the 10 × 5 meter Sprint test is designed to measure aerobic capacity and agility in children with CP GMFCS level I or II (Verschuren et al., 2007). Children must continuously sprint 10 times on the five-meter course, making turns at the cones marking the end of the five meters. A decrease of 3.2 s exercise time would be considered a significant change. It presents an excellent inter-observer reliability (ICC> 0.97) and intra-observer (r = 1). The simplicity of application of these two tests facilitates their use in clinical settings. However, to our knowledge, there is no assessment tool applicable clinically, with CP children of GFMCS IV and V levels.

In the study by Cleary et al., Aerobic capacity is measured using two tests: a test of six-minute walk and a sub-maximal stress test on a treadmill (Cleary et al., 2017). The test of 6 min walk (6MWT) is increasingly used to measure functional capacity in young people with cerebral palsy. When this test is carried out in accordance with guidelines of the American Thoracic Society, it seems to be reliable for this population (Maher et al., 2008) . However, this is not a specific measure of aerobic capacity. In addition, according to a recent review of the literature, the 6-minute walk demonstrates poor validity as a tool for assessing aerobic capacity in adults with cerebral palsy (Lennon al., 2015). It would seem even more adapted to the assessment of the locomotor capacity of the child

(Maher et al., 2008) and weakly linked to VO2max in ambulatory adolescents and young adults with CP (Slaman et al., 2013). The relevance of the use of this test on CP children for the purpose of measuring the cardiorespiratory ability is debated today (Lennon al., 2015) (Maher et al., 2008). For lack of qualified medical staff available, a sub-maximal stress test on a treadmill is also carried out at failure of a maximum stress test. Although not the gold standard, this test allows all the same to observe the evolution of the aerobic capacity during the various measurements. The difference in specificity observed between these two tests could explain the maintenance of the aerobic capacity measured at T20 during the 6-minute walk test, which is not verified at this same date during the submaximal test on a treadmill (Cleary et al., 2017). Moreover, not being significant, this result seems to be weighted.

Finally, the studies by Van Wely et al. and Nsenga et al. describe the use of a progressive test on a cycloergometer to assess the VO2max after children with CP from GMFCS I to III levels.In the light of the literature, it is a reliable tool that can potentially detect a change in cardiorespiratory condition over time (Brehm et al., 2014). Nevertheless in the study de Nsenga et al., in view of the GMFCS level (I and II) and despite the coordination disorders presented by the children included in this study, the use of a shuttle test would have probably been more suited.

Depending on their reliability and validity, these measurement tools are therefore more or less relevant. During the evaluation of aerobic capacity and its maintenance at the end of the interventions. Despite the obvious benefits of physical activity for CP children, the risks of exercise are rarely studied in the scientific literature (Van Der Slot et al., 2013) (Verschuren et al., 2007) (Pelliccia et al., 2016). In order to standardize the protocols and tools for measuring the cardiorespiratory capacity of the child CP, a systematic review was carried out in 2013 (Lennon al., 2015). The current recommendations encourage the practitioner to use specific and sensitive measurement tools, so as to ensure the safety of the child, as well as an optimal follow-up.

5.1.3. Maintaining aerobic capacity

5.1.3.1.Types of intervention

In this literature review, only the studies by Van Wely et al. and Cleary et al. measure the evolution of aerobic capacity at a distance from the procedure (Van Wely et al. 2014) (Cleary et al., 2017). Since no significant improvement is observed at the end of the stimulation of activity in the first of these two studies, cardiorespiratory capacity measured at 12 months remains unchanged. Conversely in the study by Cleary et al., A significant increase is observed in the intervention group, during the sub-maximum stress test on carpet at T10. This difference is not maintained at T20. On the other hand, well that no significant difference is noticed during the six-minute walk test, a tendency to increase the aerobic capacity of effect size d = 0.5 is to be noted at T20. The elements that could explain this ambivalence were discussed in the paragraph previous.

In view of these results, it would therefore seem that these interventions do not allow keeping the child's abilities at a distance from the program, and whether they are simple or multicomponent. This is in contradiction with the study by (Slaman et al., 2014). Indeed, this multi-component intervention improved significantly the aerobic capacity of subjects up to three months after the end of the program, thus suggesting that offering an intervention on lifestyle resulted in continued treatment effects. Just like the study of Van Wely et al., The aim of combining strategies was therefore to induce a modification of the behavior intended to maintain the desired effect over time. Nowadays, several publications support the interest of a multi-component program in order to induce the lasting change in a parameter or behavior (Mcgrane et al., 2015).

To do this, practitioners use motivational interviewing. It is a tool support for patients suffering from chronic pathologies towards a change (Mckenzie et al., 2015). It is based on attentive listening, a discussion during which the practitioner adopts an empathetic attitude. Indeed, according to the WHO, health is based on human biology, the environment, the lifestyle of the individual, and health care (World Health Organization, 2019). An approach multimodal intervention affecting the behavior and habits of the child then appears relevant when done well. In addition, according to a literature review motivational interventions would significantly increase healthy behavior in terms of physical activity (O’halloran et al., 2014). This study also suggests that physiotherapists are ideally placed to assume this role and that it would be relevant to integrate such interventions to their practice. Here, the speaker adopts an approach to promote health. Resources are then made available to support long-term behavior in the aim of preventing the onset of secondary disorders. It would seem that the effect of intervention is more important when a single outcome is targeted. On the other hand, to our knowledge, duration and type of intervention most beneficial have not yet been defined. Likewise, to date, the follow-up of the studies encountered only covers up to one year following the applied program.

5.1.3.2. Intervention sites

Since the WHO definition also involves the individual's environment, it seems that a intervention based solely on lifestyle is not sufficient to result in lasting change. The environment is also a significant element identified as a determinant of health (World Health Organization, 2019). Accessibility is one of the most important factors frequently identified by PC children and their parents to explain poor practice physical activity (Shields & Synnot, 2016). Indeed, problems related to their disabled situation such as lack of qualified personnel to run the activity, transport problems, lack of acceptance among the general population and the low rate of accessible leisure clubs are to be raised (Shields & Synnot, 2016). Therefore, the place of intervention can constitute a barrier or a facilitator to maintain activity.

In our literature review, we note that the studies by Cleary et al., Zwinkels et al. and that of Nsenga et al. take place in a specialized school (Cleary et al., 2017) (Nsenga et al., 2013) (Zwinkels et al., 2018). These two actions carried out in the child's daily living space seem to be a relevant means of promoting access to the practice of regular physical activity. Indeed, the The above-mentioned barriers to physical activity can eventually be eliminated. In Furthermore, a recent study suggested the need for school-based initiatives, as their An integrative approach is effective and targets even the least active children (Shields & Synnot, 2016). However, only the program activity conducted by the physiotherapist in Cleary's study et al. demonstrates a significant improvement in aerobic capacity. The modalities of physical activity and the practitioner responsible for its supervision therefore also appear to be elements to consider. Likewise, an intervention at the child's home as carried out in the study by Van Wely et al. appears to be a good alternative to facilitate access to the activity.

However, a study in chronic patients suggests that adherence to home exercise programs could be facilitated by enhancing the attractiveness of programs, fostering a sense of support, and also improving performance (Verschuren et al., 2016). Establishing specific goals with the child and their family, as well as that a regular evaluation of its capacities are elements of response to these requests.

The child's interests and preferences are also key activity parameters that the practitioner should take into consideration when designing the exercises. Indeed, the fun and interest of the child in the activity practiced are elements identified as promoting and improving the child's adherence to activity (Verschuren et al., 2016) (Shields & Synnot, 2016). By freeing children of these psychological barriers, the worker will promote adhesion and durability of its action.

5.1.3.3.Measuring Physical Activity

Although three studies in our literature review do not directly measure the aerobic capacity at a distance from the intervention, additional elements such as the measurement of physical activity are presented in the publications of Zwinkels et al., Cleary et al., and Van Wely et al. The recommendations of Verschueren et al. Advise lifelong regular participation in physical activity (Jette & Portney, 2003). Participation in physical activity in young people is recognized as a means contributing to well-being, and developing motor and social skills. In addition, the usual physical activity behavior during childhood has been identified as possibly extending into adulthood (Rogers et al., 2008). If the practice of regular physical activity is not included in the child's daily life, he risks to develop a risk profile for comorbidities, in particular cardiorespiratory. To date, the international guidelines on physical activity recommend that children aged 5 to 18 years engage in moderate to vigorous physical activity for at least 60 minutes each day (World Health Organization, 2019). A physically active lifestyle can confer even greater benefits important to young people with disabilities, playing an important role in their health their participation and their social and emotional well-being (Maher et al., 2007). Also, even though the cardiorespiratory capacity is not directly measured, the assessment of the level of physical activity of children seems to be a good indicator of whether or not acquired skills are maintained.

In the studies by Zwinkels et al. and Cleary et al. the measurement is carried out using a triaxial accelerometer worn by children for one week (Cleary et al., 2017) (Zwinkels et al., 2018). It is a tool making it possible to detect six types of activities in ambulatory patients: lying down, sitting, standing, walking, cycling and running. According to the literature, the questionnaires "Children Assessment of Participation and Enjoyment" (CAPE) and "Preference of Activities for Children" (PAC), assess the pleasure experienced during an activity, as well as the diversity and the intensity of participation in formal activities (organized sport, other activities based on skills, clubs, groups and organizations) and informal (recreation, sports). The level of physical activity indicates inclusion in the child's habits. It informs also on whether or not to continue the practice (King et al., 2007).

5.1.4. *Aerobic capacity and function*

Within the studies of this literature review, three publications assess the effect of intervention on subjects' function (Van Wely et al., 2014) (Cleary et al., 2017) (Lauglo et al., 2016). Among the functional aspects defined in our theoretical framework, only the capacity for mobility - including the motor capacity overall, walking ability, and functional muscle strength - and the quality of life of the child are explored. Like the scientific literature previously encountered by our study, the direct relationship between improved aerobic capacity and increased functional abilities of young CP is not explored by the publications of our review. Nevertheless, in these two articles, a correlation between the increase in aerobic capacity and improved function in the child has been reported by parents (Van Wely et al., 2014) (Lauglo et al., 2016).

In the publications by Lauglo et al. and Cleary et al., parents and children complete respectively questionnaires (KINDL10 questionnaire and CP QOLChild questionnaire) intended to assess the child's quality of life at different stages of the intervention. We can notice a common point between these two studies: the results of questionnaires completed by children do not indicate any improvement in favor of function. The methodologies of these studies do not specify the development of formulated objectives with the child and the parents beforehand. As a result, children's expectations and those of the parents may differ and lead to this disparity. We therefore recall the need to formulate common and measurable objectives. The involvement and motivation of the child for support will only be increased. Therapists and parents of children with CP find motivation a determinant key of motor and functional outcomes for this population (Tatla et al., 2013).

Moreover, if the study by Cleary et al. specifies that the selection of participants takes into account the ability to answer a simple question, the study by Lauglo et al. only mentions one adaptation of the questionnaire to the child's age. However, cognitive disorders associated with paralysis cerebral, can constitute a major bias when responding to questionnaires. The tool assessment must therefore also be adapted to the child's comprehension capacities. The scale used in the study by Lauglo et al. is a Norwegian version of the questionnaire KINDL. The latter assesses the quality of life of children and adolescents from general population, and also in young people with chronic conditions (Jozefiak et al., 2008). The questionnaire includes 24 items divided into six subscales, each item addressing the experiences of the child during the past week. It is therefore not a specific scale to cerebral palsy.

In contrast, the study by Cleary et al. uses the CP QOL questionnaire specifically developed for young people with cerebral palsy. It seems to have a high internal consistency (ICC 0.74–0.92) as well as good test-retest reliability (ICC 0.76–0.89) concerning the parents' proxy report (Mugno et al., 2007). Studies suggest that the Child Self-Assessment Questionnaire has acceptable psychometric properties. This tool measures the well-being of the child according to seven domains, including quality of life and pain level.

According to the literature, due to the disorders associated with their pathology, children with higher GMFCS experience more chronic pain (Kingsnorth et al., 2015). According to estimations based on self-report, more than 60% of children with CP are painful (Rastoden, 2015). Pain, often unrecognized, can then impact the quality of life of the child, his participation in activities of daily living, as well as his physical capacity. Since it seems to influence the functional capacities of the child and his quality of life, it appears relevant to include the assessment of the pain of the CP child during its management.

However, to date there is an obvious lack of standardization regarding the measurement of pain (Kingsnorth et al., 2015). Indeed, practitioners use many tools such as the visual analog scale (VAS), the Wong-Baker face scale or the verbal classification scale. Self-assessment by the child is however recommended in order to reflect the subjectivity of pain interference. This is the standard criteria for its Evaluation. Today most studies focus on the severity of pain but none other dimension. Thus, pain interference is rarely evaluated. Moreover, the Communication skills hamper accurate assessment. Among the tools validated to measure the intensity of pain and its impact, for example: the pain subset of Health Utilities Index Mark (Kingsnorth et al., 2015).

Based on the interpretation of our results as well as the scientific literature, it would seem that by reducing the pain level of the CP child, his physical and functional capacities improve, as well as its participation. Obstacles to the practice of physical activity being reduced, the child can then participate more in regular physical activity likely to improve their aerobic capacity in the long term. Thus, although the direct impact of the aerobic capacity on the functional capacities of the child is not explored by the literature, we note the coexisting relationship between these two elements.

In addition, in the study by Van Wely et al., We observe a tendency to improve the walking ability at 4 months and motor ability at 6 months, but no Significant improvement in aerobic capacity is noted (Van Wely et al., 2014). Despite a reduced frequency of physical activity to once a week, and unincreased aerobic capacity, improving functional capacity would therefore be possible. This questions the linearity of our initial problematization, since the hypothesis put forward described an impact of the activity on the aerobic capacity, itself at the origin of a modification of the function.

The capacity for functional mobility and postural control of the child can be assessed during the "Time up & go" (TUG). This is a simple measure that is accessible to the practitioner in clinical setting. The modified procedure for children is described by (Williams et al., 2005): participants must stand up from a chair with a backrest but no support on the arms, then they walk three meters until they hit a target, before going back to their seats. The exercise is timed and children are encouraged throughout the procedure. The TUG has high intra-session and intra-operator reliability (ICC 0.99) (Dhote et al., 2012). He is also sensitive to changes over time in children with physical disabilities (Williams et al., 2005).

In the publication by Lauglo et al., A significant decrease in Submaximal heart rate as well as the percentage of use of VO2max is observed (Lauglo et al., 2016). This testifies to a greater energy reserve and a lower relative exhaustion. These elements are therefore facilitating during activities of daily living. Nevertheless, since the absolute oxygen absorption remains unchanged, their energy consumption does not vary during activities. These results are surprising, and raise questions about the evolution of the energy expenditure index (IDE) when walking. Its measurement would inform us about the economy and efficiency of the child's walking (Maher et al., 2016). This functional indicator is calculated during regular and habitual walking for 5 minutes. This measure relates to the ratio of the average heart rate during the 5 th minute walk on the speed walk (Cristol & Bérard, 1998). It is a tool for the functional assessment of gait that is both reliable and accessible during clinical practice.

5.1.5. Summary of the interpretation of the results

At the end of this literature review, the hypothesis according to which intensive physical activity improved the child's cardiorespiratory capacity has been confirmed. Nevertheless, the practice of aerobic activity of moderate to high intensity and directed towards a goal seems also effective. Maintaining aerobic capacity and regularity of practice, involve the accessibility of the activity, as well as the adhesion of the child. Finally, if the results of Our study does not allow us to observe a direct impact between the improvements of Aerobic capacity and improved function, the relationship between these two components has been demonstrated. The importance of including pain assessment during Support for the CP child was also highlighted. Generally, it seems necessary to use specific and sensitive evaluation tools, within the framework of clinical practice.

5.2.Recommendations for practice

These recommendations describe the elements that can be included in the practice of physiotherapist, to ensure a lasting improvement in aerobic capacity in cerebral palsy children, during physical activity. The aim is to provide a relevant and quality care of the cardiorespiratory disorders of the child PC. They are established in addition to the usual rehabilitation of respiratory disorders by the practitioner. In view of our results, we are not able to distinguish care in children aged 2 to 12 years from that of children aged 13 to 21. These recommendations therefore concern the CP child aged 7 to 19 years and from GMFCS I to III levels. They are defined according to the interpretation of the results of our study, as well as current guidelines from ACSM and Verschueren et al. (Van Der Slot et al., 2013) (Jette & Portney, 2003) (Rogers et al., 2008). The elements that can be included in the practice of physiotherapy in order to ensure lasting improvement in aerobic capacity in children with cerebral palsy, during practice of physical activity.

5.2.1. Modalities of physical activity

5.2.1.1.Preparation for the activity and recovery

An active aerobic warm-up of low to moderate intensity, that is, less than 70% of the VO2max is recommended (Zois et al., 2015). When immediately followed by a short recovery before the start of the activity, warming up reduces pain. Activo-dynamic stretching can also be done as close as possible to the situation of effort (Gedda, 2015). These two elements will promote the activation of muscle tone. They limit also pain, as well as the risk of muscle injury. A time of relaxation or rest at the end of the effort, offers children a better recovery.

5.2.1.2.Type of activity

Regarding the type of activity practiced, we recommend aerobic type exercises and soliciting all muscle groups. Exercises performed at a continuous rhythm, and with the prior establishment of a goal to be achieved by the child can be performed during activities such as walking, running, group games, or even pedaling on a cycloergometer (Rogers et al., 2008) It is preferable that activity groups consist of 2 to 5 children (Verschuren, et al., 2016) (Shields & Synnot, 2016). At-beyond this number, the adaptation of the care and the safety of the child will be less.

5.2.1.3.Intensity

Regarding the intensity, it is recommended to carry out an activity of intensity between 60% and 95% of HRmax, between 50% and 65% of VO2max, or between 40% and 80% of RHr (44) (Rogers et al., 2008). Intensity should gradually increase throughout the program training.

5.2.1.4.Frequency and duration

Sessions of 2 to 4 times per week, for at least 20 minutes are recommended (Rogers et al., 2008) (Jette & Portney, 2003). When the intervention is carried out at least 3 times a week, an intervention for at least 8 weeks is necessary to improve aerobic capacity. In the other hand, if the child only practices twice a week, 16 weeks are necessary for the improvement of cardiorespiratory parameters (Jette & Portney, 2003). As previously mentioned, a progression of the duration of the sessions and their frequency each week, must be observed throughout the training program.

5.2.2. Child's adhesion

The child's adherence will induce a regularity of the practice, as well as an inclusion of physical activity in his lifestyle. These habits are likely to lead to cardiorespiratory and functional benefits until adulthood. Before the intervention, we suggest the formulation of objectives respecting the “SMARTs” principles, in partnership with the child and his parents. It is important to include the parents in the care of the child, and ensure that they understand the pathology of the child and its evolution (Bovend'eerdt et al., 2009). It is also better to talk to the child on his preferences in order to direct the care towards activities likely to lead to the sustainable maintenance of the activity and its integration into daily life. Likewise, the practice of the activity in a group of 2 to 5 children promotes fun and adherence of the child (Verschuren et al., 2016). Participation and continuation of activity will only increase.

The physiotherapist can use motivational interviewing. The objective is to support the child in modifying his sedentary behavior, and promote physical activity and its benefits (O'halloran et al., 2014) (Tatla et al., 2013).

The practitioner must also allow the child to overcome environmental barriers recognized (Verschuren et al., 2016). In order to facilitate access to rehabilitation, management can be carried out at the child's home, in a rehabilitation center or during interventions within his educational establishment. When this is not possible, rehabilitation can be carried out in a liberal office.

5.2.3. Assessment tools

In order to improve the quality and relevance of the care, the use of specific measures by the physiotherapist is recommended. They will warn also the risks associated with cardiorespiratory disorders during intensive physical activity. These assessments can be done at the start and at the end of rehabilitation, but also on a regular basis during the treatment.

Subject of the evolution	**Measuring tool**
Goal attainment	• GAS scale (Krasny-Pacini et al., 2013) • COPM measure (Tam et al.,2008)
Aerobic capacity	• Shuttle test (Balemans et al., 2013) • Sprint test (De Groot et al., 2012) Associated with the measurement of heart rate, saturation, and dyspnea with the Borg scale (Williams, 2017)
Pain interference	• Index of health utilities (Kingsnorth et al., 2015)
Capacity for mobility and balance	• Time up & go (Dhote et al., 2012)
Cost and efficiency of operation	• Energy expenditure index (Maher et al., 2016)
Proven pleasure and participation	• CAPE questionnaire (King et al., 2007) • PAC questionnaire (King et al., 2007)
Quality of life	• CPQOL questionnaire (Mugno et al., 2007)

Table 13. summary of the assessment tools during the care of the CP child

5.3.The limits

The questioning around our research subject led us to consult many scientific articles but for all that, the conclusions of our study remain incomplete due to various biases linked to the context, as well as to the outlines of the subjects treated in the literature.

5.3.1. Limitations concerning the methodology

When establishing our inclusion and exclusion criteria, we decided to integrate results on aerobic capacity and its maintenance, but also on the function of the child. Therefore, in three of the publications of our review, aerobic capacity is not the primarily measured outcome, but rather a secondary outcome. This does not respect the prioritization of the objectives of our study which prioritized the measurement of aerobic capacity. In addition, this literature review includes publications presenting subjects suffering from cerebral palsy, but also other chronic pathologies. Thus, one of our studies does not only involve children with cerebral palsy, but also participants with neurological, musculoskeletal, metabolic or cardiovascular problems. The interpretation of the results of this publication is therefore not specific to CP children.

5.3.2. Limits regarding recommendations

First of all, it is important to emphasize that our literature review is based on heterogeneous studies. Indeed, if we started this research work with the intention of including only randomized controlled trials, we quickly realized that the low number of studies meeting our inclusion criteria would not allow the establishment of an exhaustive literature review. Faced with this observation, we then made the choice to include also non-randomized controlled trials. However, this decision implies lowering the level of proof of our study, since according to the established levels of evidence by HAS, our review includes level 2 and 4 studies (Lauglo et al., 2016). This corresponds to grades of recommendations B and C, i.e. studies respectively leading to a “Scientific presumption” or “low level of scientific evidence”.Moreover, in all of these publications, the experts conclude by the impossibility to extend recommendations to children PC. The strength of recommendation of our study can therefore be qualified as weak (Lauglo et al., 2016).

Likewise, we have chosen to focus our questioning on CP children. presenting GMFCS levels I to V. However, in our literature review, only the article by Lauglo et al. studies the impact of the intervention on PC children from GMFCS I to IV levels. Well that the functional level of the population in the publication by Zwinkels et al. do not be detailed, we note that none of the studies presented in our work include of participants at GMFCS V level. This therefore constitutes a new bias in our study, since our recommendations cannot extend to the entire expected population. On the other hand, the studies of our work, based on the practice of "physiotherapists", the transferability of the interpretation of the results will only be possible if it concerns shared competences. Finally, although this work is based on articles published during over the past 10 years, new studies exploring our subject of investigation have not been used in this work since they are in progress.

Given all the biases identified during this study, the recommendations previously formulated are established with regard to the literature, but they cannot be standardized for the entire target population. They are not considered to be scientific evidence.

6. Conclusion

6.1. Professional contributions

Due to this work We were allowed to deepen our knowledge of the management of the patient with cerebral palsy and its associated disorders. But above all, we realized the importance of promoting access to physical activity among these patients, in order to overcome the constraints encountered daily. During this discovery, physical activity applied to patients with disabilities, had already aroused our interest. To date, this work has reinforced our desire to orient our practice towards sports physiotherapy, applied to the rehabilitation of neurological disorders. We also aspire to participate in preventive interventions in the field of disabled sports. Our vision of the profession of physiotherapist is above all that of a exchange of experiences and knowledge, aimed at improving the health and well-being of the patient on a daily basis. In view of the complexity of the disorders associated with cerebral palsy, and neurological pathologies in general, communication with the patient and his adherence to the care plan are essential concepts.

6.2. Outlook

At the end of this literature review, we see a clear need for interventions which are accessible and promoting the adhesion of the child with cerebral palsy to the practice of a regular physical activity. Despite the obvious benefits of physical activity in CP children, the risks of exercise are only rarely studied in the scientific literature. In addition, the clinical assessment of aerobic capacity during effort is less practiced when caring for the child with CP. During this work, we found strong evidence for the reliability and validity of measures of aerobic capacity (shuttle test) based on the field. However, most available assessment tools concerning children classified at levels I and II of the GMFCS. Further Clinical studies on field measurements for children of GMFCS levels III to V, are needed today. In fact, considering their profile, these children are more risky of sedentary lifestyle, development of cardiorespiratory disorders and cardiovascular comorbidities. It is therefore the healthcare professional's responsibility to take reasonable precautions, especially when doing high intensity activity. To this day it is necessary to establish a reliable, valid, relatively inexpensive, and easy to perform test with CP children of all GMFCS level.

6.3.Opening

In order to promote their adhesion, physiotherapists could accompany the children in a process of commitment to exercising a sport that responds to their preferences and their goals. This would allow the sustainable practice of a physical activity. Such interventions could also be carried out in schools, with the collaboration of teachers. A recent randomized controlled study, explores the means available to the physiotherapist to offer children a transition from individual physiotherapy, towards the practice of leisure sports. An intervention of 8 weeks will thus be conducted with schooling CP children and GMFCS I and II level, in a community park. The results of this study are expected to add a growing body of of evidence supporting group physiotherapy and interventions in collective settings.

Currently, few physiotherapists are engaged in collective actions of prevention and public health. By creating a conductive environment to the development of personal aptitudes of the CP child, the physiotherapist adopts an anticipatory and educational approach. It is an interdisciplinary and coordinated action, motivated by the child's health and well-being.

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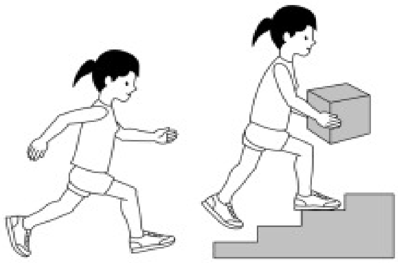
8. Supplementation

8.1.List of Table

8.2.List of figures

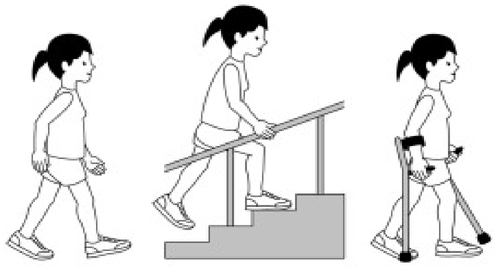
Table of Annexe

Annex 1: Gross Motor Function Classification Scale (GMFCS)



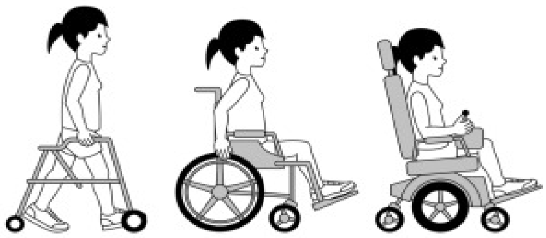
GMFCS Level I

Youth walk at home, school, outdoors and in the community. Youth are able to climb curbs and stairs without physical assistance or a railing. They perform gross motor skills such as running and jumping but speed, balance and coordination are limited.



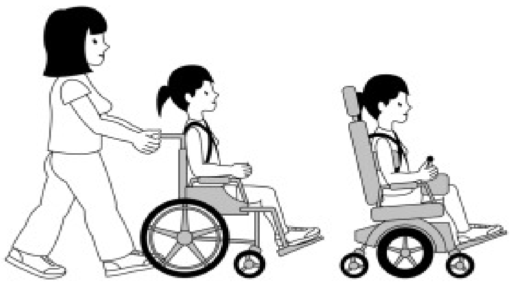
GMFCS Level II

Youth walk in most settings but environmental factors and personal choice influence mobility choices. At school or work they may require a hand held mobility device for safety and climb stairs holding onto a railing. Outdoors and in the community youth may use wheeled mobility when traveling long distances.



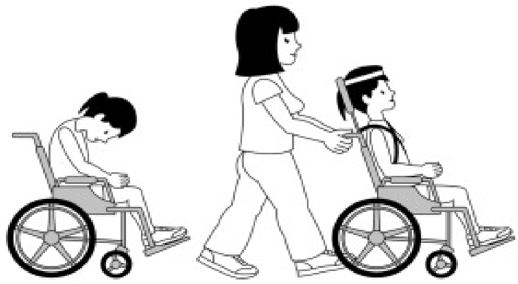
GMFCS Level III

Youth are capable of walking using a hand-held mobility device. Youth may climb stairs holding onto a railing with supervision or assistance. At school they may self-propel a manual wheelchair or use powered mobility. Outdoors and in the community youth are transported in a wheelchair or use powered mobility.



GMFCS Level IV

Youth use wheeled mobility in most settings. Physical assistance of 1-2 people is required for transfers. Indoors, youth may walk short distances with physical assistance, use wheeled mobility or a body support walker when positioned. They may operate a powered chair, otherwise are transported in a manual wheelchair.



GMFCS Level V

Youth are transported in a manual wheelchair in all settings. Youth are limited in their ability to maintain antigravity head and trunk postures and control leg and arm movements. Self-mobility is severely limited, even with the use of assistive technology.

GMFCS descriptors: Palisano et al. (1997) Dev Med Child Neurol 39:214-23
CanChild: www.canchild.ca

Annex 2: Classification of intensity of physical activity

TABLE 1.2. Classification of Physical Activity Intensity

	Relative Intensity		Absolute Intensity Ranges (METs) Across Fitness Levels			
Intensity	**$\dot{V}O_2R$(%) HRR (%)**	**Maximal HR (%)**	**12 METs $\dot{V}O_{2max}$**	**10 METs $\dot{V}O_{2max}$**	**8 METs $\dot{V}O_{2max}$**	**6 METs $\dot{V}O_{2max}$**
Very light	<20	<50	<3.2	<2.8	<2.4	<2.0
Light	20–<40	50–<64	3.2–<5.4	2.8–<4.6	2.4–<3.8	2.0–<3.1
Moderate	40–<60	64–<77	5.4–<7.6	4.6–<6.4	3.8–<5.2	3.1–<4.1
Vigorous (hard)	60–<85	77–<94	7.6–<10.3	6.4–<8.7	5.2–<7.0	4.1–<5.3
Vigorous (very hard)	85–<100	94–<100	10.3–<12	8.7–<10	7.0–<8	5.3–<6
Maximal	100	100	12	10	8	6

HR, heart rate; HRR, heart rate reserve; METs, metabolic equivalents (1 MET = 3.5 mL · kg^{-1} · min^{-1}); $\dot{V}O_{2max}$, maximal volume of oxygen consumed per minute; $\dot{V}O_2R$, oxygen uptake reserve.

Adapted from (18,24,55).

Classification of intensity of physical activity (Ferguson, 2014)

Light <3.0 METs	Moderate 3.0 – 6.0 METs	Vigorous >6.0 METs
Walking	Walking	Walking, jogging & running
Walking slowly around home, store or office = 2.0*	Walking 3.0 mph = 3.3*	Walking at very very brisk pace (4.5 mph) = 6.3*
	Walking at very brisk pace (4 mph) = 5.0*	Walking/hiking at moderate pace and grade with no or light pack (<10 lb) = 7.0
		Hiking at steep grades and pack 10–42 lb = 7.5–9.0
		Jogging at 5 mph = 8.0*
		Jogging at 6 mph = 10.0*
		Running at 7 mph = 11.5*
Household & occupation		
Sitting — using computer work at desk using light hand tools = 1.5	Cleaning — heavy: washing windows, car, clean garage = 3.0	Shoveling sand, coal, etc. = 7.0
Standing performing light work such as making bed, washing dishes, ironing, preparing food or store clerk = 2.0–2.5	Sweeping floors or carpet, vacuuming, mopping = 3.0–3.5	Carrying heavy loads such as bricks = 7.5
	Carpentry — general = 3.6	Heavy farming such as bailing hay = 8.0
	Carrying & stacking wood = 5.5	Shoveling, digging ditches = 8.5
	Mowing lawn — walk power mower = 5.5	
Leisure time & sports		
Arts & crafts, playing cards = 1.5	Badminton — recreational = 4.5	Basketball game = 8.0
Billiards = 2.5	Basketball — shooting around = 4.5	Bicycling — on flat: moderate effort (12–14 mph) = 8.0; fast (14–16 mph) = 10
Boating — power = 2.5	Bicycling — on flat: light effort (10–12 mph) = 6.0	Skiing cross country — slow (2.5 mph = 7.0; fast (5.0–7.9 mph) = 9.0
Croquet = 2.5	Dancing — ballroom slow = 3.0; ballroom fast = 4.5	Soccer — casual = 7.0; competitive = 10.0
Darts = 2.5	Fishing from river bank & walking = 4.0	Swimming — moderate/hard = 8–11†
Fishing — sitting = 2.5	Golf — walking pulling clubs = 4.3	Tennis singles = 8.0
Playing most musical instruments = 2.0–2.5	Sailing boat, wind surfing = 3.0	Volleyball — competitive at gym or beach = 8.0
	Swimming leisurely = 6.0†	
	Table tennis = 4.0	
	Tennis doubles = 5.0	
	Volleyball — noncompetitive = 3.0–4.0	

MET equivalents of common physical activities classified as light, moderate or vigorous intensity (Williams, 2017)

Annex 3 : Evaluation scales of internal validity

1. Eligibility criteria were specified	no ☐ yes ☐ where:
2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ☐ yes ☐ where:
3. Allocation was concealed	no ☐ yes ☐ where:
4. The groups were similar at baseline regarding the most important prognostic indicators	no ☐ yes ☐ where:
5. There was blinding of all subjects	no ☐ yes ☐ where:
6. There was blinding of all therapists who administered the therapy	no ☐ yes ☐ where:
7. There was blinding of all assessors who measured at least one key outcome	no ☐ yes ☐ where:
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ☐ yes ☐ where:
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ☐ yes ☐ where:
10. The results of between-group statistical comparisons are reported for at least one key outcome	no ☐ yes ☐ where:
11. The study provides both point measures and measures of variability for at least one key outcome	no ☐ yes ☐ where:

Figure 4. Pedro scale

Modified Newcastle-Ottawa quality assessment scale
cohort studies

No.	Criterion	Decision rule	Score (*=1, no*=0)
SELECTION			
1	Representativeness of the exposed cohort	a) Consecutive eligible participants were selected, participants were randomly selected, or all participants were invited to participate from the source population* b) Not satisfying requirements in part (a), or not stated.	
2	Selection of the non-exposed cohort	a) Selected from the same source population* b) Selected from a different source population c) No description	
3	Ascertainment of exposure	a) Structured injury data (e.g. record completed by medical staff)* b) Structured interview* c) Written self-report d) No description	
4	Demonstration that outcome of interest was not present at the start of the study	a) Yes* b) No or not explicitly stated	
COMPARABILITY			
1	Comparability of cohorts on the basis of the design or analysis	a) Study controls for age* b) Study controls for birth weight* *Note*: Exposed and non-exposed individuals must be matched in the design and/or confounders must be adjusted for in the analysis. Alone statements of no differences between groups or that differences were not statistically significant are not sufficient.	
OUTCOME			
1	Assessment of outcome	a) Independent or blind assessment stated, or confirmation of the outcome by reference to secure records (e.g. imaging, structured injury data, etc.)* b) record linkage (e.g. identified through ICD codes on database records)* c) Self-report with no reference to original structured injury data or imaging d) No description	
2	Was follow-up long enough for outcomes to occur?	a) Yes (≥12 months)* b) No (<3 months)	
3	Adequacy of follow up of cohorts	a) Complete follow up – all participants accounted for* b) Subjects lost to follow up unlikely to introduce bias (<20% lost to follow up, or description provided of those lost*) c) Follow up rate <85% and no description of those lost provided d) No statement	
SCORE			

Figure 5. Modified Newcastle-Ottawa quality assessment scale