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Aerobic capacity in children and adolescents with cerebral palsy

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ABSTRACT

This study described the aerobic capacity [VO_{2peak} (ml/kg/min)] in contemporary children and adolescents with cerebral palsy (CP) using a maximal exercise test protocol. Twenty-four children and adolescents with CP classified at Gross Motor Functional Classification Scale (GMFCS) level I or level II and 336 typically developing children were included. All children performed a progressive exercise test on a treadmill with respiratory gas-exchange analysis. The results are compared with normative values for age and gender-matched controls. Aerobic capacity of children and adolescents with CP, who are classified at GMFCS level I or II was significantly lower than that of typically developing controls. Especially in girls with CP, the aerobic capacity deteriorated with age. The aerobic capacity of contemporary children and adolescents with CP, who are classified at GMFCS level I or II is significantly lower than that of typically developing controls.

The peak oxygen uptake (VO_{2peak}) attained during graded maximal exercise to volitional exhaustion is considered by the World Health Organization as the single best indicator of aerobic physical fitness (Shephard, Allen, Benade, Davies, & Di Prampero, 1968). This variable, commonly expressed as the volume oxygen consumed per unit of time relative to body mass (ml/kg/min) (Rowland, 1991) is also a valid indicator of health status (Myers et al., 2002) and a powerful predictor of mortality in both healthy and diseased individuals (Blair, Cheng, & Holder, 2001). There is strong scientific evidence that youth with low aerobic capacity are more likely to display additional risk factors for cardiovascular disease such as elevated blood pressure and serum cholesterol levels (Carnethon et al., 2003; DuRant et al., 1993; Tolfrey, Campbell, & Jones, 1999).

Besides a health indicator, serial testing of aerobic capacity of children and adolescents with CP can be useful to provide a quantitative assessment of the change in the condition of the patient after for example an exercise rehabilitation program or can be helpful for the monitoring of athletic training (Unnithan, Clifford, & Bar-Or, 1998).

To date, only four studies (Hoofwijk, Unnithan, & Bar-Or, 1995; Lundberg, 1984; Maltais, Pierrynowski, Galea, & Bar-Or, 2005; Rieckert, Bruhm, & Schwalm, 1977) have studied the VO_{2peak} in children and adolescents with cerebral palsy (CP) during a maximal exercise test. Only two of these studies compared the VO_{2peak} to the values in typically developing children and adolescents (Hoofwijk et al., 1995; Lundberg, 1984). Both studies concluded that the aerobic capacity of children with CP is reduced compared to typically developing children.

The most functional and appropriate way to assess the VO_{2peak} in children with CP who are able to walk independently, is a progressive walking or running-based maximal exercise test (Verschuren, Takken, Ketelaar, Gorter, & Helders, 2006). From three studies there is data available on VO_{2peak} in children with CP, that is based on a maximal exercise test on a treadmill

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(Hoofwijk et al., 1995; Maltais et al., 2005; Rieckert et al., 1977). Hoofwijk et al. (1995) included 9 children with CP and compared the VO_{2peak} to the values in typically developing children and adolescents. The studies performed by Rieckert et al. (1977) and Maltais et al. (2005), examining respectively 12 and 11 children with CP did not compare the results with typically developing children, but provided useful information on VO_{2peak} values for children with CP.

The current available data on VO_{2peak} in children with CP is based on a small number of children. Therefore, the purpose of this article is to describe the VO_{2peak} in a group of contemporary children and adolescents with CP who are able to walk independently, using a maximal treadmill protocol, with the results being compared with normative values for age and gender. These results will be compared with the findings of earlier studies that assessed VO_{2peak} of children with CP using a maximal exercise test on a treadmill test. Moreover, the differences between Gross Motor Functional Classification Scale (GMFCS) level I and II will be assessed as well.

1. Method

1.1. Participants

Twenty-four participants with CP (16 boys and 8 girls), classified at GMFCS level I and II, participated in a previously published study that examined the reliability and validity of two newly developed shuttle run tests (SRT-I and SRT-II) to measure aerobic capacity in children and adolescents with CP (Verschuren et al., 2006). A secondary analysis of the previously collected data was conducted (Verschuren et al., 2006).

1.2. Typically developing reference group

The patient group was compared with reference values obtained in a group of 336 active, healthy controls who were recruited from regular schools in The Netherlands. All participants performed a progressive treadmill exercise test to exhaustion (Binkhorst, Hof van het, & Saris, 1992). Continuous respiratory gas analysis and minute ventilation (VE), peak oxygen uptake (VO_2), and carbon dioxide production (VCO_2), were performed using comparable equipment as in a previous publication (Verschuren et al., 2006). The respiratory exchange ratio (RER) was calculated from the collected data (=VCO_2/VO_2). The healthy reference group was matched with the children and adolescents with CP according to age and gender.

1.3. Measurements

Anthropometry. Prior to testing, each child was weighed on electronic scales (Seca, Hamburg, Germany). Height measurements were taken on the same visit while the child was standing against a wall. Body composition was assessed using the sum of 4 skin fold measurements. The skin fold measurements were taken at 4 sites on the right side of the body (triceps, biceps, subscapular and suprailiac) by 2 investigators (OV and TT) in accordance with the American College of Sports Medicine guidelines (Armstrong, Whaley, Brubaker, & Otto, 2005). Body composition was reflected by the body mass index (BMI). The BMI was calculated as weight in kilograms divided by height in meters squared. Participants' weight and height were measured using a standard protocol. Each child was weighed to the nearest 100 g on electronic scales (Seca, Hamburg, Germany). Height was measured to the nearest 0.5 cm using a stadiometer.

GMFCS. The GMFCS, translated into the Dutch language, was used by a pediatric physical therapist (OV), who was experienced in using the GMFCS, to classify the children and adolescents with CP into groups based on their functional mobility. Level I represents the highest level of functional abilities, and level V represents the lowest level of functional abilities. Due to the physical demands of the tests, only children and adolescents who were classified at GMFCS level I (able to walk indoors and outdoors and climb stairs without limitation) or level II (able to walk indoors and outdoors and climb stairs holding on to a railing, but experience limitations in walking on uneven surfaces and inclines and in walking in crowds or confined spaces) were recruited. The original GMFCS has been reported to yield reliable and valid data for children aged 6–12 years (Palisano, Rosenbaum, & Walter, 1997). Children over 12 years of age were classified using the expanded and revised version of the GMFCS (GMFCS-E&R) (Palisano, Rosenbaum, Bartlett, & Livingston, 2008).

Physical characteristics of the patient group (according to GMFCS level) and the reference group have been summarized in Table 1 for completeness of data. There were no significant differences between the groups.

1.4. Progressive exercise test

Progressive exercise testing on a treadmill was performed on all subjects using a previously developed protocol for CP (Verschuren et al., 2006). Subjects with a level I or II classification on the GMFCS each performed a different protocol. The subjects who were classified at level I on the GMFCS started at a speed of 5 km/h with a increment of 0.25 km/h every minute, and the subjects who were classified at level II on the GMFCS started at 2 km/h with an increment of 0.25 km/h every minute.

All children were instructed to run until exhaustion. One subjective and two objective criteria were used to determine if the test was maximal. Every child had to meet the subjective criterion and one of the two objective criteria. The physiological criteria were: heart rate $>$ 180 beats/min (Schulze-Neick, Wessel, & Paul, 1992) and a respiratory exchange ratio (RER) $>$ 0.99 (Armstrong & Welsman, 2008). Subjective criteria were signs of intense effort such as unsteady running pattern, sweating,