Is physical activity of children with cerebral palsy correlated with clinical gait analysis or physical examination parameters?

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1. Introduction

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain (Rosenbaum et al. 2007). The overall prevalence of CP is 1.77 per 1000 live births. Cerebral palsy is the largest cause of motor disability in childhood (Sellier et al. 2016). The benefits of regular physical activity on health are widely recognized, especially by World Health Organization (WHO, 2010). Children with cerebral palsy practice less daily physical activity (PA) than typically developing (TD) children (Maher et al. 2007). This may affect their quality of life and may increase their impairments. This study proposes to determine the correlations between clinical gait analysis (3-DGA) and clinical examination with physical activity. The hypothesis is that correlations are not strong enough to estimate physical activity from 3-DGA or physical examination parameters.

2. Methods

Children with CP, aged 11 – 18, with GMFCS I – II are included. Physical activity is recorded with an Actigraph GT3X during 7 days (Clanchy et al. 2011). The parameters computed from the accelerometer data were the percentage spent in moderate to vigorous physical activity (MVPA) and steps per day respectively qualifying the intensity and the quantity of physical activity (WHO, 2009). Children also filled a complete diary of their daily activity in order to validate the consistency of the accelerometer recording. All patients had a 3-DGA and a standardized clinical examination. A set of 54 parameters was selected from the kinematic and spatio-temporal data (Benedetti et al. 1998). Clinical examination resulted in 29 parameters, including strength, selectivity, and range of motion. The levels of association between kinematics and spatio-temporal parameters, physical examination measurements, average daily step count, and MVPA were tested with a Spearman’s rank correlation coefficient (rho). A multiple regression analyses was carried out in order to determine which combination of independent variables from 3-DGA or clinical examination best predicts physical activity parameters. Only independent variables with significance level of 0.05 and rho>0.4 were included in the models. The significance level was 0.05, the best model was chosen according to the coefficient of determination ($R^2$). All statistics were performed with R 3.3.3. Altman’s guidelines were considered to interpret the correlations: poor, rho<0.2; fair, 0.21-0.40; moderate, 0.41-0.60; good, 0.61-0.80; very good, 0.81-1.00.

3. Results and discussion

25 patients have been included. The mean GDI (Schwartz and Rozumalski, 2008) was 74 (range, 46-96), the mean time spent in MVPA was 113 minutes (range, 31-227) and the mean steps per day was 5483 (range, 1781-11377). Only 4 patients reached the WHO recommendations of physical activity (more 10.000 steps per day and more than 60 minutes MVPA per day). The mean percentage spent in sedentary activity was 77% (range 52-90). Daily diary of patients has shown they have practised some sports and exercises after school. The essential of the physical activity recorded is induced by locomotion and school playtime.

The GDI showed no correlation with the percentage of time spent in MVPA, but with the number of steps per day (rho=0.41, p<0.004). These results are similar to those found by Wilson i.e. a moderate association between the GDI and the average daily step count (rho = 0.58) (Wilson et al. 2015). Hip, knee and ankle kinematics parameters
were fairly correlated with PA (rho<0.40). Fair to moderate correlations were founded between the spatio-temporal parameters and PA.

Walking-speed didn’t correlate with PA. Some clinical measurements were correlated with PA, but none of these exceeded rho=0.6 (i.e. good correlation). All the correlations founded are summarised in tables 1 and 2.

Data recorded by 3-DGA focus on the walking activity in laboratory situation and this examination is not aimed to be representative of the wide variety of motor activities experimented by children. However, when treatments are indicated to improve the gait quality the secondary purpose is often to contribute to an improved PA and furthermore to an improved social participation. Our results suggest that improving gait quality may not systematically lead to an improvement of the level of physical activity, because there is no link between quality of walking and level of physical activity.

The multiple regression models for MVPA and steps per day prediction were respectively created from 7 and 8 kinematic and clinical examinations parameters. Both models showed R²-values <50%, indicating that physical activity can’t be strongly predicted by 3-DGA and clinical examination parameters.

### 4. Conclusions

If some kinematics, spatio-temporal parameters and clinical examination parameters are correlated with intensity and quantity of physical activity, the links found in this study are not enough to predict physical activity from 3-DGA and physical examination.

Gait analysis and clinical examination could very partially reflect the overall level and quantity of daily physical activity. None of the tested models from 3-DGA and clinical examination strongly predicts PA. Regarding the weakness of the observed correlations, we recommend to associate 3-DGA and actimetry in the longitudinal follow-up of patients with CP. Furthermore, if the benefits of treatments such as Single Event Multi Level Surgery have already been demonstrated concerning gait, it would be interesting to test its effects on physical activity on children with CP.

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**Table 1. Correlations between 3-DGA and PA variables**

| MVPA | Steps/day |
|------|-----------|
| GDI  | 0.41**    |
| Time of TO | -0.29* |
| Hip Flexion at TO | -0.33* |
| Knee Flexion at HS | -0.30* |
| Ankle Flexion at HS | -0.32* |
| Cadence | 0.33* |
| Cycle duration | -0.37** |
| Stance duration | -0.42** |
| Swing duration | -0.34* |

*p < 0.05; **p < 0.01.
IC: initial contact; TO: toe-off; HS: heel strike.

**Table 2. Correlations between clinical examination and PA variables**

| MVPA | Steps/day |
|------|-----------|
| Hip Flexory | -0.35* |
| Hip Flexory ROM | 0.54*** |
| Hip External Rotation ROM | 0.49*** |
| Hip Abduction ROM | 0.52*** |
| Hip Flexors | 0.36* |
| Knee Extensors | 0.35* |
| Knee Flexors | 0.39** |
| Hip Abductors | 0.38** |
| Ankle Plantar Extensors | 0.29* |

*p < 0.05; **p < 0.01; ***p < 0.001.