Activity Capacity in Children with Early Onset Scoliosis Compared to Pulmonary Function (Spirometry) and Patient Reported Outcomes

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INTRODUCTION: The primary outcome of importance in early onset scoliosis (EOS) is considered pulmonary function, but it is challenging to measure in young children. Surrogate measures, including thoracic length and Cobb angle are often used, but are poorly predictive of patient outcomes. Activity capacity as determined by metabolic equivalents of task (MET) is potentially an effective alternative to pulmonary function testing (PFTs). Utilizing the MET values published for activities in healthy children within the youth compendium (METy) may provide an opportunity to determine activity capacity rather than just lung volumes, but it is unclear whether these are valid in EOS or are related to PFTs. The purpose of this pilot study was to evaluate whether MET values for activities of varying intensity in children with EOS are equivalent to and demonstrate similar orders of magnitude as published METy and to evaluate the relationships between PFT, scoliosis characteristics, maximum steady-state treadmill speed achieved, patient-reported outcomes measures (PROM), and MET values of various activities.

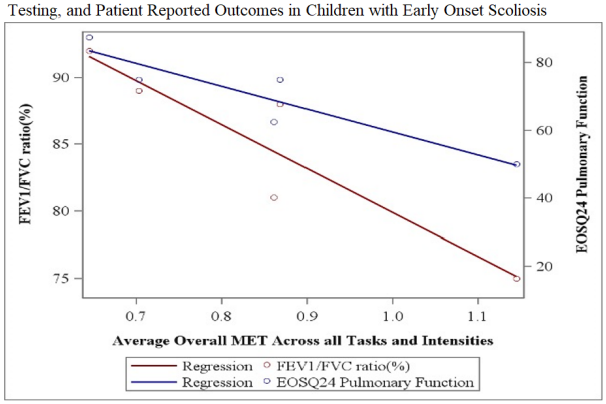
METHODS: In this observational cross-sectional pilot study, eight children (ages 6-16y, 50% female) completed testing. Scoliosis parameters obtained included Cobb angles and spinal lengths (T1-12). Relative resting metabolic rate and physical activity MET values were measured using indirect calorimetry. Individualized MET values were computed while performing two different tasks. Using video games performed with a Nintendo Switch, three tasks were chosen that represented low (bowling), moderate (boxing), or high intensity (active running) activities. Additionally, treadmill walking was performed at speeds corresponding to low, moderate, or high intensity. The treadmill speed was determined using METy values similar to the corresponding active video game intensity, and individual child feedback during practice sessions. EOS assessed MET values were compared to age-matched compendium METy values for similar tasks. Resting respiratory rate and lung function parameters using spirometry, FEV1, FVC, and FEF_{25-75} were assessed. All lung function parameters were analyzed and accepted based on ATS and ERS standards. Percent predicted lung function values were based on international normative data derived from arm span. EOS 24-item questionnaire (EOSQ24) results were obtained for each subject. A linear mixed model with intensity, activity, and group as fixed factors and subjects as a random factor were used to assess differences between groups. Pearson correlation coefficients were also used to assess relationships between variables. All procedures were approved by the Institutional Review Board at UNC Chapel Hill.

RESULTS: The average major Cobb angle for participants was 63° (range 35-138°), with 5 subjects <50° and 3 >50°. Participants had prior surgery (n=3), bracing (n=3), and casting (n=1). Scoliosis etiology was congenital (n=6) idiopathic (n=2). Five participants had severe restriction with both FVC and FEV1 less than 50% predicted. The average scores for the EOSQ24 were 70 (range 41-91) overall, 63 (13-100) for pulmonary function, 81 (42-100) for physical function, and 61 (25-100) for fatigue/energy. The ability to complete the tasks ranged from all eight participants for the easy and moderate for the Nintendo Switch activities and the easy treadmill activity, whereas only five participants completed the hard treadmill activity. Children with EOS had a statistically significant 0.6 MET lower overall mean MET value compared to published METy values ($p<0.001$), primarily due to the 1.2 MET difference when using the Nintendo Switch ($p<0.001$). When examining individual tasks, both the easy and moderate intensity Nintendo Switch activities were statistically significantly lower than the corresponding published METy values ($p<0.001$), while there was no difference for the other four tasks. An increase in intensity corresponded with an increase in MET value when comparing the hard intensity to moderate and easy intensities ($P<0.001$), but not when comparing moderate to easy intensities ($p=0.319$). The FEV1/FVC ratio had a strong negative correlation with the percent predicted average MET values for treadmill tasks ($R=-0.881$, $p=0.049$) and across all tasks ($R=-0.927$, $p=0.024$). Pulmonary function EOSQ24 also had negative correlations with the Nintendo Switch ($R=-0.785$, $p=0.037$), treadmill ($R=-0.885$, $p=0.046$), and across all tasks ($R=-0.992$, $p=0.026$).

DISCUSSION: This study found the relationship between increasing intensity and published METy was largely retained in EOS, except with the easy/moderate Nintendo Switch activities. This is likely because the published values used older games which behave differently, and the current games can readily be played using wide variations in intensity. Children unable to generate higher MET values appear to self-limit their activity. PFT's demonstrating severe restrictive lung disease show higher MET than normal children and low EOSQ24 Pulmonary Function Scores.

SIGNIFICANCE: This pilot study is the first in EOS to assess MET determined activity capacity and its relationship with patient outcome and function. MET determined activity capacity shows promise as a means to further define and measure lung function in children with Early Onset Scoliosis.

Figure 1. Correlations between Metabolic Equivalents of Task, Pulmonary Function Testing, and Patient Reported Outcomes in Children with Early Onset Scoliosis



Average overall MET values were transformed into percent of predicted compendium MET values. Correlations for MET values were only performed for those with complete data. Abbreviations: EOSQ-24, early onset scoliosis 24-item questionnaire; FEV1/FVC, forced expiratory volume in 1 second/forced vital capacity