The Effect of Different Treadmill Speeds on the Variability of V\textsubscript{O}\textsubscript{2} max in Children*

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Summary. Eight boys aged 10–12 years performed three tests on each of three treadmill protocols. Each test was a continuous, progressively graded performance to exhaustion, but protocols differed in speed – (walk: 90 m \cdot \text{min}^{-1}, jog: 110 m \cdot \text{min}^{-1}, run: 130 m \cdot \text{min}^{-1}). The walk protocol was found inappropriate for V\textsubscript{O}\textsubscript{2} max determination in children. Compared to the faster speeds, the walk test elicited a lower V\textsubscript{O}\textsubscript{2} at exhaustion, and had lower reliability (0.56) and a high coefficient of variation (8%). For the V\textsubscript{O}\textsubscript{2} at exhaustion on the jog and run protocols the coefficient of variation was 3–5% and the reliability coefficient averaged 0.90, comparable to values seen for repeated trials in adults. The usually accepted V\textsubscript{O}\textsubscript{2} max criterion of a plateau of V\textsubscript{O}\textsubscript{2} with increasing work levels was inappropriate for use with children. Attempts to derive plateau criteria suitable for use with children proved unsuccessful. Plateau criteria may be difficult to achieve with children in light of their apparently weaker glycolytic energy capacity. Nevertheless, the highest V\textsubscript{O}\textsubscript{2} measured at jog or run speeds has a consistency similar to that found for V\textsubscript{O}\textsubscript{2} max measurement in adults.

Key words: Graded exercise testing – V\textsubscript{O}\textsubscript{2} max plateau – Intra-individual variation – Reliability

The objective measurement of maximal oxygen uptake (V\textsubscript{O}\textsubscript{2} max) in children appears to be more difficult than in adults, and the accuracy of the measurement of aerobic power in children has been questioned (Cumming and Friesen 1967; Shephard et al. 1969). The major problem is the identification of a maximal effort in children. A plateau of oxygen uptake (i.e., an increase of < 2.1 ml \cdot \text{kg}^{-1} \cdot \text{min}^{-1} with an increase in work) has often been used to identify a true V\textsubscript{O}\textsubscript{2} max. Such a plateau has not been observed on a regular basis with children.

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(Åstrand 1952; Cumming and Friesen 1967; Stewart and Gutin 1976; Cunningham et al. 1977); failure to achieve a plateau may be associated with a reduced reliability of measurement of VO2 max in children (Cunningham et al. 1977). In light of the importance of the VO2 max measure in assessing the overall performance of the gas transport system it is necessary to establish the relative consistency with which aerobic power can be measured in children.

The commonly used treadmill protocols which accurately determine VO2 max have been designed for adults and assessed and validated in adult studies (Shephard et al. 1968; Maksud and Coutts 1971; Davies 1972; McArdle et al. 1973; Froelicher et al. 1974; Stamford 1975; McKay and Banister 1976; Pollock 1976; Knowlton et al. 1977), and may not be appropriate for use in children. For testing of children, most investigators have chosen a protocol of progressive grade increments (usually 2–5%), but the speeds selected have varied from a walking pace (Skinner et al. 1971; Stewart and Gutin 1976; Boileau et al. 1977) to a running stride (Shephard et al. 1969).

Thus, difficulties encountered in the assessment of VO2 max in children may be the result of: 1) unrealistic plateau criteria, 2) inappropriate test protocols, or 3) physiological differences in the exercise response of children compared to adults. The purposes of the present study were: 1) to establish the consistency and intra-individual variability of VOa max of children using three treadmill speeds, and 2) to investigate plateau criteria for the objective assessment of VO2 max in children.

**Material and Methods**

Eight 10–12 year old boys were recruited as volunteer subjects, with parental consent. The mean age was 11.4 years; mean body weight was 36.9 kg, SD ± 7.5; and mean height was 146.7 cm, SD ± 7.4. Six of the boys were very active in sports. Each boy completed nine maximal treadmill tests (three tests of each of three different exercise protocols) over a 3–4 week period, with an interval between tests of 24–72 h. Each boy was tested at the same time of the day. The boys did not eat 2 h prior to each test. Prior to the start of each test the boys rested quietly for 15 min. The boys were instructed and encouraged to exercise to exhaustion.

All exercise tests were done in a laboratory at temperatures of 20–23°C. A motor driven treadmill was used and belt speed checked during each test. Oxygen uptake was determined throughout each test by the open circuit technique. Subjects breathed through a Koegel valve. Inspired minute ventilation was continuously measured by a dry gas meter, and expired gases were sampled from an 8 l mixing pot for analyses of O2 (paramagnetic analyzer) and CO2 (infrared analyzer) concentrations. Gas analyzers were previously calibrated against gases of known concentrations (Scholander 1947). Heart rate (fc) was monitored throughout the test, from a bipolar chest lead (CM5). Data were analyzed for the last minute of each work level and for each of the last 2 min of a test. A post-exercise blood sample was taken from a finger-tip for blood lactate (LA) analysis (Hohorst 1965).

The nine treadmill tests were divided into three blocks. Each protocol was carried out once in random order within each block. All protocols were continuous in nature with initial grade of 0%, with 2.5% grade (sine of angle) increments every second minute. The protocols differed in treadmill speed as follows: 1) Walk: 90 m · min⁻¹ (3.4 m.p.h.), 2) Jog: 110 m · min⁻¹ (4.1 m.p.h.), and 3) Run: 130 m · min⁻¹ (4.9 m.p.h.). The test duration averaged 18 min for walk, 13.9 min for jog, and 11.4 min for run. In conjunction with the run protocol a 6 min warm-up (0% grade, 130 m · min⁻¹) was