

Reliability of a wheelchair transfer test to determine the maximal aerobic capacity of a 26 year old wheelchair tennis player with arthrogryposis

Kaelin C. Young*, Helen M. Bannon*, Nathan W. Wadsworth, Chase C. Curtiss,
Jeremy A. Patterson

Department of Kinesiology and Sport Studies, College of Education

Abstract. The purpose of the study was to assess the reliability of a maximal aerobic capacity transfer test performed on an individual confined to a wheelchair living with arthrogryposis. **Methods:** A 26 year-old, world-ranked wheelchair quad tennis player with arthrogryposis underwent 4 identical multi-stage wheelchair transfer tests. The first 3 being 3 days apart and the 4th 10 weeks later, to measure maximal aerobic capacity (VO_{2max}). The individual performed transfers between chairs at an increasing tempo until exhaustion. HR_{max} and plateau of VO_2 were used as indices of metabolic stress at the end of the VO_{2max} test. **Results:** Data from Test 1 and Test 2 (17.8 and $22.1 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) shows an increase in aerobic capacity between tests by 19%. Test 2, 3, and 4 (22.1 , 23.0 , $21.8 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) elicited a mean difference of 3.3%. HR_{max} was consistent throughout the 4 tests (181 bpm, 179 bpm, 179 bpm, and 181 bpm respectively). **Conclusions:** These data suggest that arthrogryposis patients with limited upper limb mobility can safely perform a maximal aerobic capacity test by means of transferring. A familiarization test is necessary for a reliable assessment of maximal aerobic capacity.

1. Introduction

Anthrogryposis multiplex congenita (AMC) is a rare syndrome occurring in approximately 1 in 3000 births [1]. It is characterized by the presence of joint contractures affecting multiple body areas at the time of birth. Individuals classified with arthrogryposis share five common clinical characteristics: 1) affected extremities lack muscle tone and may be spindle-shaped (narrower at the ends when compared to the middle) with a lack of normal skin creases; 2) dislocation of joints, particularly the hips or knees; 3) rigidity of joints; 4) atrophy and/or absence of muscle groups, and 5) have intact sensation [2]. Joint contractures occur while in the womb due to fetal akinesia (lack of fetal movement). Joint formation in the fetus is normal. However, due to a lack of movement several muscles or muscle groups are underdeveloped or absent which are replaced by fat and thick fibrotic tissue impairing joint mobility [3]. Depending upon the extent of contractures, some individuals are non-ambulatory and confined to wheelchairs. Due to lack of mobility in the upper extremities, motorized wheelchairs are often used.

Measuring aerobic capacity in wheelchair confined individuals with limited upper limb mobility is difficult. Most wheelchair confined individuals used in aerobic capacity studies have full use of their upper extremities and are able to propel themselves accordingly. Testing protocols for measuring aerobic capacity in wheelchair confined individuals traditionally use arm crank or wheelchair ergometry [4]. However, these protocols are impractical for individuals with limited upper arm mobility and joint stability. To our knowledge, there are no protocols that have been designed specifically for this population. We propose a transfer test as an alternative protocol to assess maximal aerobic capacity. The purpose of this study was to assess the reliability of a maximal aerobic capacity transfer test performed on an individual confined to a wheelchair living with arthrogryposis.

2. Methods

A 26 year old, world-ranked male quad wheelchair tennis player with arthrogryposis underwent four identical multi-stage wheelchair transfer tests. The first three being three days apart and the 4th 10 weeks later, to measure maximal aerobic capacity (VO_{2max}).

Protocol

Informed consent and baseline measurements of weight and blood pressure were obtained. Resting heart rate and VO_2 measures were recorded with the subject seated in his wheel chair.

Maximal aerobic capacity ($\text{VO}_{2\text{max}}$) was analyzed using a PhysioDyne Instrument metabolic cart with a Max II oxygen analyzer (# Pml111E), and a carbon dioxide analyzer (# 1r1507). Exercise heart rate was measured using a Polar Heart Rate monitor. The test protocol consisted of a wheelchair to stationary chair transfer test. The subject used his own motorized wheelchair, which was locked in place with the front of the wheelchair perpendicular to the stationary chair. The subject was instructed to transfer between chairs at an increasing tempo until exhaustion. Testing protocol consisted of multi-stages each lasting 90 seconds. A transfer was initiated every 14 seconds during the first stage and accelerated by 2 seconds for each following stage therefore increasing the number of transfers throughout. The last stage consisted of the subject transferring as fast as possible until volitional exhaustion.

3. Results

Table 1 shows $\text{VO}_{2\text{max}}$ values from tests 1 through 4. Data from Test 1 and Test 2 show an increase in aerobic capacity between tests by 19% (Table 2). $\text{VO}_{2\text{max}}$ for Test 2, 3, and 4 were consistent, eliciting a mean difference of 3.3%. The difference between $\text{VO}_{2\text{max}}$ of Test 1 and the mean of test 2, 3, and 4 was 20%. Maximal heart rates were consistent through the 4 tests (Table 1).

Table: 1

Max VO_2 and Heart Rate scores for all tests		
Test	$\text{VO}_{2\text{max}}$ ($\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	Heart Rate (bpm)
1	17.8	181
2	22.1	179
3	23.0	179
4	21.8	181

Table: 2

% VO_2 difference between tests	
Test	% Difference
1-2	19
1-3	23
1-4	18
2-3	4
2-4	1
3-4	5

4. Discussion

To our knowledge there are no published studies assessing self transferring as a means to measuring exercise capacity. It is known by the authors that there are other methods for assessing aerobic capacity for wheelchair individuals, however due to the unique condition of our subject these methods were not possible.

The results show a greater percentage difference of $\text{VO}_{2\text{max}}$ between Test 1 and Tests 2 through 4 (Table 2). This implies there was a learned effect between Test 1 and Test 2. Similarly, heart rate maximum values were consistent throughout all 4 tests suggesting that the differences in oxygen utilization between Tests 1 and Test 2 can be contributed to increases in mechanical efficiency. These data suggest a need for a familiarization trial.

Although these results are for a single subject, the data presented suggests that the seated transfer VO_2 test is a reliable measure of $\text{VO}_{2\text{max}}$ when a familiarization test is performed. However, further testing with a larger sample size is necessary to determine statistical significance for a reliability test

5. Conclusions

These data suggest that arthrogryposis patients with limited upper limb mobility and joint stability can safely perform a maximal aerobic capacity exercise test by means of transferring. It is also suggested that a familiarization test is necessary for a reliable assessment of maximal oxygen consumption.

References

- [1] J.G. Hall. (1997). Arthrogryposis multiplex congenita: etiology, genetics, classification, diagnostic approach, and general aspects. *J Pediatr Orthop B*, 6, 159-66.
- [2] H. S. Lee. (2005). Amyoplasia Congenita of the lower extremity: report in a premature baby. *Yonsei Med J*, 46 (4), 567-70.
- [3] M. Freivogel. (2005). Amyoplasia. *The Gale Encyclopedia of Genetic Disorders* (2nd Ed.). Farmington Hills: Thomson Gale.
- [4] J.L. Durstine &G.E. Moore. (2003). *ACSM's Exercise Management for Persons with Chronic Diseases and Disabilities* (2nd Ed.). Champaign: Human Kinetics.