

Validation of a Step Test in Children Ages 7-11

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Background

- Exercise Testing
 - Maximal Testing
 - Sub-maximal testing
- Modified step test protocol



Research Question

1. Can a submaximal step test be developed to accurately predict maximal aerobic capacity in children?
2. What are the best predictors of maximal aerobic capacity?
 1. Anthropometric measurements
 2. Heart rate response
 3. Step height

Purpose

- The purpose of this study is to design a portable and reproducible, validated step test that predicts peak aerobic capacity in healthy children ages 7-11 years old, that can be administered by health care professionals, educators, and caregivers in a variety of settings.



Hypothesis

- By creating a submaximal step test that will adjust to the height of each child, and measuring their heart rate at numerous times, we believe, an accurate prediction of aerobic capacity can be obtained.

Methods

- Subjects
- Anthropometrics
- Sub-maximal Test
- Peak Aerobic Capacity



Subjects

- 128 male and female children
- Inclusion Criteria
 - Healthy male and female children, ages 7-11
- Exclusion Criteria
 - Diagnosed disorders made worse with exercise
 - Non-English speakers without interpreter present during all components of the study
- Recruiting
 - A.T. Still University, YMCA, Community

Anthropometric Measurements

- Height and weight
- Blood pressure
 - Resting & Recovery
- Body circumferences
- Skin fold



Sub-maximal Test

- 2, 3-minute step tests
 - Instruction provided
 - Step height calculated
 - Resting HR established
 - Metronome set at 104 beats/min
 - HR taken immediately following completion, 15 & 30 seconds, 1,2 & 3 minutes
 - Second test with alternate step height

Step Height (inches) Based on Child's Height

Step Height	Gender	Age: 7	8	9	10	11
8	F	<40.74	<40.74	<40.12	<39.81	<39.36
	M	<40.90	<40.90	<40.58	<39.96	<39.51
10	F	40.74-51.62	40.74-51.62	40.12-50.83	39.81-50.44	39.36-49.88
	M	40.90-51.82	40.90-51.82	40.58-50.42	39.96-50.63	39.51-50.06
12	F	51.62-62.49	51.62-62.49	50.83-61.07	50.44-60.39	49.88-60.39
	M	51.82-62.74	51.82-62.74	50.42-61.25	50.63-61.30	50.06-60.61
14	F	62.49-73.36	62.49-73.36	61.07-72.25	60.39-71.70	60.39-70.90
	M	62.74-73.66	62.74-73.09	61.25-73.09	61.30-71.98	60.61-71.16

Peak Aerobic Capacity

- Continuous, incremental, walking and running protocol on a treadmill was used.
- Running speed was adapted to each subject through 3-5 minute familiarization session.

Peak Aerobic Capacity

- Each stage was 2 minutes in duration
 - Stage 1: 2.5 mph, 0% grade
 - Stage 2: x.x jogging speed, 0% grade
 - Stage 3: x.x jogging speed, 6% grade
 - Stage 4: x.x + 0.3 mph, 6% grade
 - Stage 5: x.x + 0.6 mph, 6% grade
 - Stage 6: x.x + 0.9 mph, 6% grade
- If fatigue is not accomplished by minute 12, grade was increased 2% every 2 minutes

Statistical Analysis

- Pearson's Correlation Coefficient (r)
 - Anthropometric measurements
 - HR responses at all time points and step heights
 - Peak aerobic capacity
- Stepwise Regression
 - ANOVA—determined if regression model was significant or not

Results

- Subject Characteristics
- Blood pressure and BMI
- Anthropometric Measurements
- HR response to Step Test
- VO₂ by age x gender
- Predictive Models
- Development of the Models



Subject Characteristics

Age, yr	7	8	9	10	11
Female (n)	7	10	9	5	7
Male (n)	5	8	11	8	5
Height, cm	F: 49.68 M: 48.90	F: 50.68 M: 50.09	F: 53.69 M: 53.61	F: 56.35 M: 56.59	F: 60.59 M: 57.20
Body Mass, kg	F: 27.72 M: 26.36	F: 27.27 M: 25.00	F: 36.15 M: 37.34	F: 38.05 M: 38.25	F: 47.57 M: 36.01
BMI, kg/m ²	F: 17.59 M: 17.40	F: 16.50 M: 15.76	F: 19.12 M: 19.82	F: 18.56 M: 18.34	F: 19.94 M: 17.06
SBP, mmHg	F: 108.57 M: 93.20	F: 104.40 M: 107.13	F: 114.00 M: 115.09	F: 108.40 M: 111.63	F: 120.86 M: 113.60
DBP, mmHg	F: 76.29 M: 69.20	F: 68.20 M: 71.00	F: 76.44 M: 74.27	F: 69.60 M: 74.38	F: 73.43 M: 70.80

Anthropometrics												
		Circumference Measurements (cm)								Skinfolds (mm)		HR
Age	Sex	Arm	Forearm	Waist	Abdomen	Buttocks	Hips	Mid-thigh	Calf	Triceps	Calf	BPM (Resting)
7	Female	20.29	19.38	22.44	61.89	72.49	66.95	35.58	27.04	17.95	19.19	90.95
	Male	19.84	19.00	58.17	59.82	65.74	64.86	33.69	24.44	18.20	17.53	83.02
8	Female	19.40	18.40	55.27	60.41	68.39	65.18	33.08	25.98	16.33	16.66	88.20
	Male	18.02	18.06	55.54	58.03	66.06	63.00	35.96	25.33	12.24	13.32	86.25
9	Female	23.67	19.35	63.36	69.17	77.91	74.13	37.98	30.71	21.30	19.52	86.25
	Male	22.56	20.70	65.03	68.58	76.93	73.02	39.96	29.56	25.95	30.12	95.27
10	Female	22.60	21.04	62.22	66.79	77.13	74.31	39.08	30.16	19.80	19.20	89.80
	Male	22.06	26.71	63.43	65.72	77.06	75.82	38.86	29.42	21.25	22.50	83.88
11	Female	24.39	22.26	68.96	76.45	87.31	84.86	42.83	32.81	17.95	20.05	92.71
	Male	21.32	20.33	61.90	64.03	77.69	73.22	38.36	28.83	14.80	14.94	79.00

Heart Rate Response to Step Test

Time Recorded	Average High HR
Resting HR	$87.24 \pm 10.69, 1.24$
Immediate	$157.24 \pm 16.22, 1.87$
15 sec	$147.77 \pm 16.34, 1.89$
1 min	$102.16 \pm 19.88, 2.30$
2 min	$94.00 \pm 15.85, 1.83$
3 min	$95.17 \pm 14.21, 1.64$

Development of Predictive Models

- Correlation analysis and ANOVA
- Direct Entry Regression
 - Age, and Gender
- Stepwise Entries
 - All Heart Rate Time Points & Step Heights
 - HR at Immediate Post Exercise, High step
 - All Anthropometric Data
 - BMI Category AND Body Fat

Development of Predictive Models

Peak VO₂ Correlated to HR Response in Low Step and High Step Conditions

	Low step	High step
Immediately	-0.645	-0.685
15 seconds	-0.584	-0.663
1 minute	-0.493	-0.492
2 minute	-0.453	-0.424
3 minute	-0.413	-0.407
Rest	-0.402	-0.387

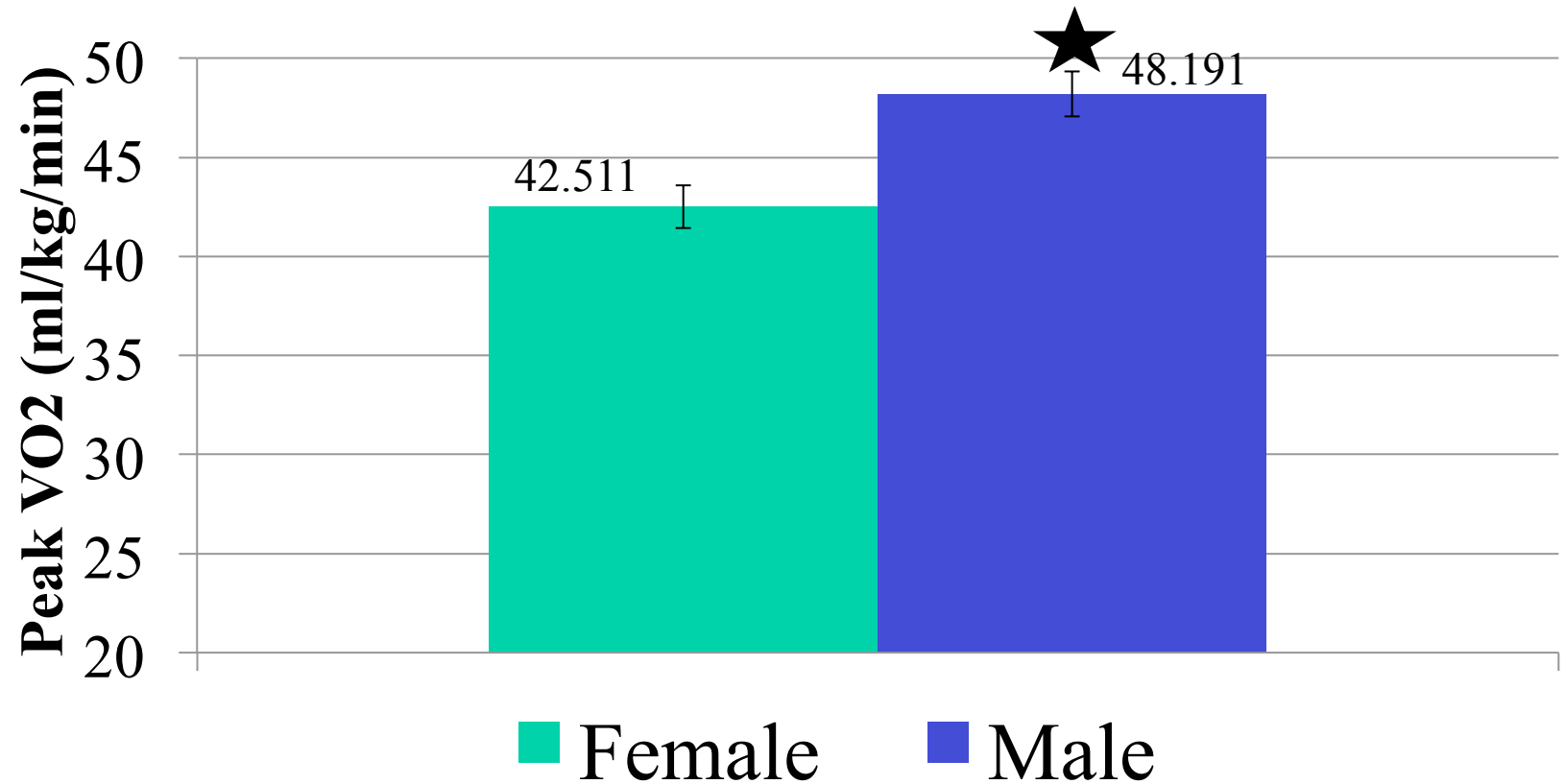
Development of Predictive Models

Correlations of BMI to Body Fat Percentage Chart

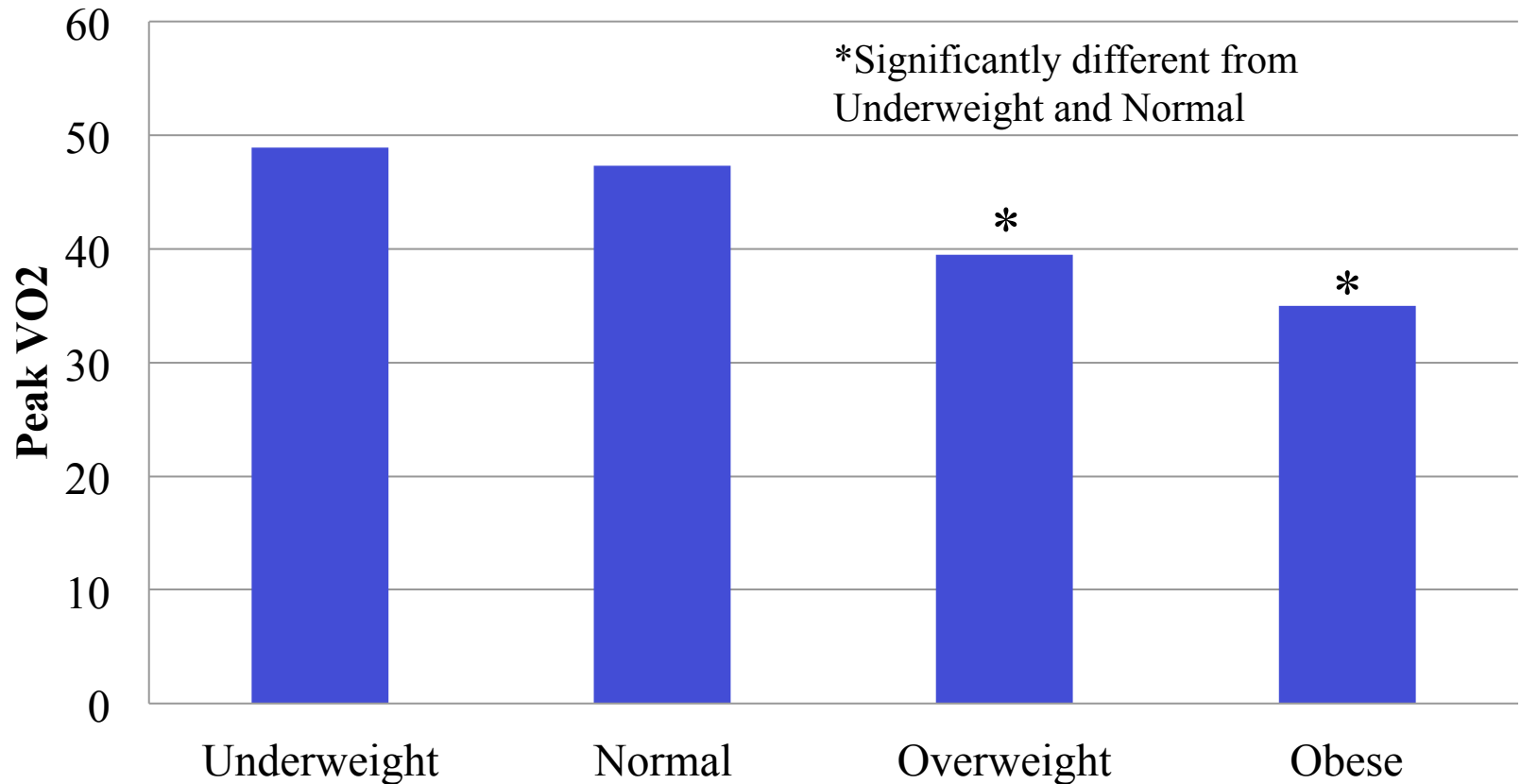
Anthropometric Measures	Body Fat Percentage (from skin folds)	BMI
Arm	0.709	0.913
Forearm	0.203	0.328
Waist, cm	0.653	0.882
Abdomen	0.686	0.893
Buttocks_hips	0.626	0.838
Hips_thigh	0.565	0.794
Midthigh	0.483	0.730
Calf	0.588	0.782
Circumference total	0.745	0.917
Body fat percentage	-----	0.809

VO₂ (ml/kg/min)

Gender



Peak VO2 By BMI Category



Correlation for BMI Category & VO2: $R = 0.605$, $p < 0.01$

Predictive Models

- Predictive Model 1

- $\text{VO2ml/kg} = 69.324 - (\text{HR Immed_H} * 0.178) + (\text{Age} * 0.582) + (\text{Gender} * 3.553) - (\text{BMI_Category} * 2.388) - (\text{Bodfat} * 0.130)$

- R^2 : 0.632

- Predictive Model 2

- $\text{VO2ml/kg} = 71.439 - (\text{HR Immed_H} * 0.198) + (\text{Age} * 0.58) + (\text{Gender} * 2.935) - (\text{BMI_Category} * 3.727)$

- R^2 : 0.610

Gender: 1=female, 2= male

Discussion

- Validation of predictive model
- Comparison to other literature.



Conclusion

- In conclusion, a submaximal step test was designed and validated that predicted peak aerobic capacity in healthy children ages 7-11 years old that can be administered by health care professionals, educators, and caregivers in a variety of settings.

Next Steps

- Next Step
 - Perform step tests in community
 - Create national norms / percentile ranks



References

We thought you may ask that...

- Predictive Model 1-15 sec:
 - $\text{VO2ml/kg} = 66.287 - (15 \text{ sec_H} * 0.170) + (\text{Age} * 0.678) + (\text{Gender} * 3.430) - (\text{BMI_Category} * 2.504) - (\text{Bodfat} * 0.139)$
 - $R^2 : 0.627$
- Predictive Model 1-60 sec:
 - $\text{VO2ml/kg} = 49.964 - (1 \text{ min_H} * 0.054) + (\text{Age} * 0.331) + (\text{Gender} * 4.719) - (\text{BMI_Category} * 2.845) - (\text{Bodfat} * 0.198)$
 - $R^2 : 0.548$

- Predictive Model 2-15sec:
 - $\text{VO2ml/kg} = 67.980 - (15 \text{ sec_H} * 0.190) + (\text{Age} * 0.684) + (\text{Gender} * 2.767) - (\text{BMI_Category} * 3.975)$
 - $R^2 : 0.601$
- Predictive Model 2-60 sec:
 - $\text{VO2ml/kg} = 48.672 - (1 \text{ min_H} * 0.053) + (\text{Age} * 0.276) + (\text{Gender} * 4.071) - (\text{BMI_Category} * 5.247)$
 - $R^2 : 0.494$