Topic 7:
Wingate Anaerobic Test

Laboratory Manual Section 07

HPHE 6720

Dr. Cheatham

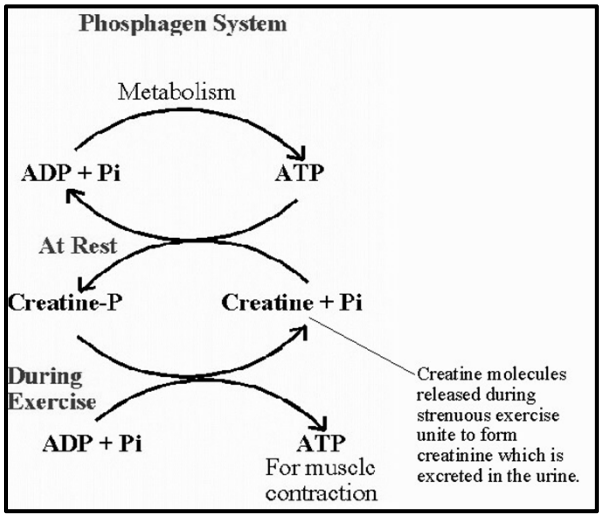
Origins

- Developed at the Wingate Institute in Israel by Dr. Oded Bar-Or in the late 1970's
- Originally developed for use in children but was expanded to adults
- One of the most widely performed tests to assess anaerobic power

Physiological Rationale

- Performance during the test is primarily dependent on the combination of the anaerobic energy pathways:
  - Phosphagen System
  - Glycolytic System
  - Approximately 85% of ATP production during the test is accounted for by these systems.
- The WAnT requires a power level that is usually 2-4 times greater than the participant's VO_{2max}.

Physiological Rationale



Variables that are Assessed

- **Peak Anaerobic Power (Pk-AnP)**
  - A reflection of the ability of the limb muscles to produce high mechanical power in a short time.
  - Peak power observed (usually over a 5 second period) during the 30-sec test.
  - Typically occurs within the first 5-8 seconds of the 30-sec test.
  - Is thought to mostly reflect the participant's ability to use the phosphagenic system.
  - However, the glycolytic pathway is probably also significantly involved
  - Expressed both in absolute terms (Watts) and relative to the participant's bodyweight (Watts/kg)

Variables that are Assessed

- **Mean Anaerobic Power (M-AnP)**
  - Reflects the endurance of the limb muscles (i.e. their ability to maintain extremely high power.
  - The average anaerobic power over the 30-sec test
  - Glycolytic pathway appears to contribute most to the participant's mean aerobic power
    - ~ 49% of ATP production
  - Phosphagen system also contributes
    - Subjects reduced there phosphagen levels to 70% of their original ATP values and 40% of their original CP values after performing the test.
  - Expressed in both absolute terms (Watts) and relative to the participant's bodyweight (Watts/kg)

Variables that are Assessed

- **Total Work (w)**
  - The total work is based upon the number of revolutions at the end of the 30-sec test
  - Expressed in both absolute terms (N·m; J) and relative to the participant's bodyweight (J/kg)
- **Fatigue Index (FI)**
  - The degree of decrease in power from the peak anaerobic power to the lowest anaerobic power.
  - Typically 40% or more

Variables that are Assessed

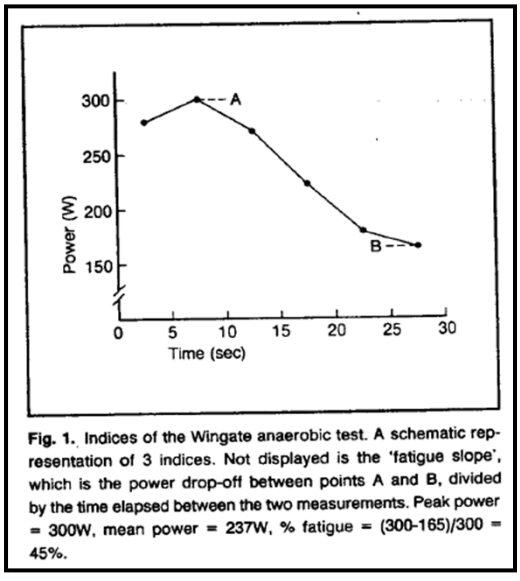


Fig. 1. Indices of the Wingate anaerobic test. A schematic representation of 3 indices. Not displayed is the 'fatigue slope', which is the power drop-off between points A and B, divided by the time elapsed between the two measurements. Peak power = 300W, mean power = 237W, % fatigue = (300-165)/300 = 45%.

Performing the Test

- Protocol has five distinct time periods:
  - Prior Exercise
    - 5 min cycling at low intensity interspersed with 4-5 sprints of 4-6 seconds at prescribed force
  - Recovery Interval
    - 2-5 minutes of rest or cycling against minimal force
  - Acceleration Period
    - 1st Phase: cycle for 5-10 seconds at one-third of prescribed force at 20-50 RPM
    - 2nd Phase: Cycle 1-5 seconds against approach to prescribed force at maximal RPM
    - Alternate: Have subject reach maximal RPM's against no-load and drop the basket immediately at maximal RPM's
  - Wingate Test
    - Cycle at highest RPM's possible against prescribed force for 30 seconds
  - Cool-Down Period
    - 2-3 minutes of cycling at low to moderate aerobic power level

Methodological Considerations

- **Optimization of Force**

Table I. The optimal load for yielding the highest mean power, based on the prototype Wingate anaerobic test and on subsequent studies

Subjects	Limb	Force (kp/kg)		Work (J/rev/kg)	References
		Monark	Fleisch		
Adult males					
Sedentary	Legs	0.075	0.045	4.41	Ayalon et al. (1974)
Active and athletes	Legs	0.098	0.059	5.76	Evans & Quinney (1981)
Phys. ed. students	Legs	0.087	0.052	5.13	Dotan & Bar-Or (1983)
Soldiers	Legs	0.094	0.056	5.53	Patton et al. (1985)
Phys. ed. students	Arms	0.062	0.037	3.62	Dotan & Bar-Or (1983)
Adult females					
Phys. ed. students	Legs	0.085	0.051	5.04	Dotan & Bar-Or (1983)
Phys. ed. students	Arms	0.048	0.029	2.82	Dotan & Bar-Or (1983)
13- to 14-year-old boys					
Active, non-athlete	Legs	0.070	0.042	4.13	Dotan & Bar-Or (1983)
13- to 14-year-old girls					
Active, non-athlete	Legs	0.067	0.040	3.92	Dotan & Bar-Or (1983)

Methodological Considerations

- **Optimization of Force (cont'd)**
  - General recommendations when using Monark cycle ergometer
    - Adult Non-Athletes: 0.090 kp/kg body weight
    - Adult Athletes: 0.100 kp/kg body weight

Methodological Considerations

- **Duration of Test**
  - Have ranged from 30 seconds to 2 min.
  - General consensus is that a 30 second test is optimal.
- **Motivation**
  - General consensus is that conventional encouragement of feedback does not affect results

Methodological Considerations

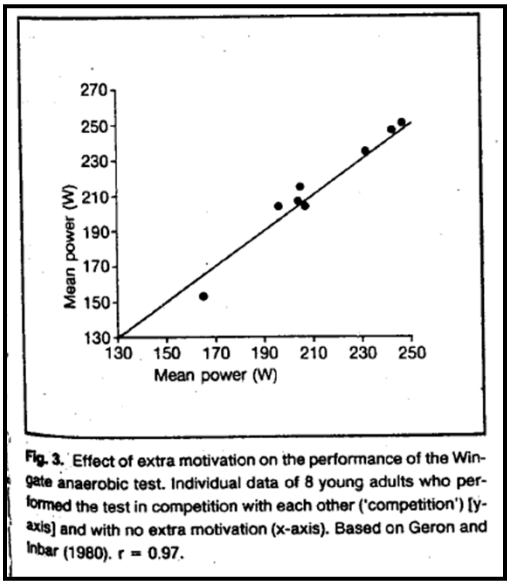


Fig. 3. Effect of extra motivation on the performance of the Wingate anaerobic test. Individual data of 8 young adults who performed the test in competition with each other ('competition') [y-axis] and with no extra motivation (x-axis). Based on Geron and Inbar (1980). r = 0.97.

Methodological Considerations

- **Warm-Up**
  - One study showed that a 15 minute intermittent warm-up (30 seconds on, 30 seconds off) on a treadmill increased mean power by ~7% but had no effect on peak power.
  - Regardless, warm-up should be standardized.

Reliability of the Wingate Test

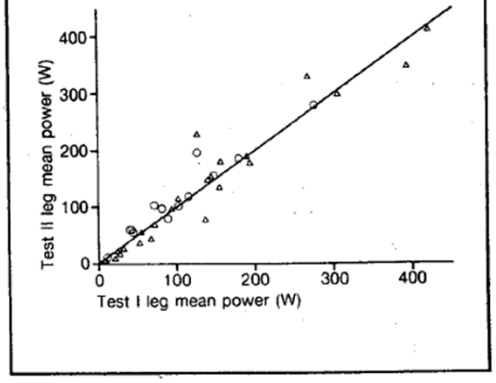


Fig. 2. Test-retest reliability of the Wingate anaerobic test. 38 children and adolescents with cerebral palsy and muscular dystrophies/atrophies performed the leg test on 2 separate days (△ = boys; ○ = girls) [Bar-Or, unpublished data]. r = 0.96.

Reliability of the Wingate Test

Table II. Test-retest reliability of the Wingate anaerobic test (WAT)

Subjects	r	Comments	Reference
Children and young adults	0.95-0.97	Several experiments	Bar-Or et al. (1977)
18 elderly, COPD patients	0.89	Abbreviated WAT	Berman & Bar-Or (unpublished)
12 active or athletic young adults	0.96		Evans & Quinney (1981)
9 phys. ed. students and athletes	0.95-0.97		Kaczkowski et al. (1982)
28 10- to 12-year-old girls and boys	0.89-0.93	3 climates, 2-week intervals	Dotan & Bar-Or (1983)
19 military personnel	0.91-0.93		Patton et al. (1985)
58 6- to 20-year-old, neuromuscular disease	0.94-0.98	Arm test	Tirosh et al. (1987)
38 6- to 20-year-old, neuromuscular disease	0.96	Leg test	Tirosh et al. (1987)

Abbreviations: COPD = chronic obstructive pulmonary disease.

Validity of the Wingate Test

Table III. Correlation between Wingate anaerobic test (WAT) scores and the performance in 'anaerobic' performance tasks

WAT index	No. and sex	Exercise	r	Comments	Reference
PP	35M	40m run speed	0.84	10-15 year-olds, random sample	Bar-Or & Inbar (1978)
PP	9M	50m run time	−0.91	Active young adults	Kaczkowski et al. (1982)
PP	24M	4 × 91.5m skate	0.83	10-year-old ice hockey players	Rhodes et al. (1985)
PP/kg	56M	50 yard time	−0.69	10-15-year-olds, active	Tharp et al. (1985)
PP	56M	Vertical jump	0.70	10-15-year-olds, active	Tharp et al. (1985)
PP	8?	500m skate speed	0.66	US National team	Thompson et al. (1986)
PP	24M	SAS40	0.32	Junior A ice hockey players	Watson & Sargeant (1986)
MP	9F&M	25m swim time	−0.90	8-12-year-old swimmers	Inbar & Bar-Or (1977)
MP	9F&M	25m swim time	−0.92	8-12-year-olds, WAT arm	Inbar & Bar-Or (1977)
MP	22F&M	300m run time	−0.88	8-12-year-old swimmers	Inbar & Bar-Or (1977)
MP	35M	300m run speed	0.85	10- to 15-year-olds, random sample	Bar-Or & Inbar (1978)
MP	24M	4 × 91.5m skate	0.71	10-year-old ice hockey players	Rhodes et al. (1985)
MP/kg	56M	50 yard time	0.69	10- to 15-year-olds, active	Tharp et al. (1985)
MP	56M	Vertical jump	0.74	10- to 15-year-olds, active	Tharp et al. (1985)
MP	24M	SAS40	0.79	Junior A ice hockey players	Watson & Sargeant (1986)
MP	8?	500m skate speed	0.76	US National team	Thompson et al. (1986)
MP	10M	300m cycle time	< −0.75	25.7-year-old cyclists	Perez et al. (1986)

Abbreviations: PP = peak power; MP = mean power; SAS40 = Sargeant Anaerobic Skate test.

Validity of the Wingate Test

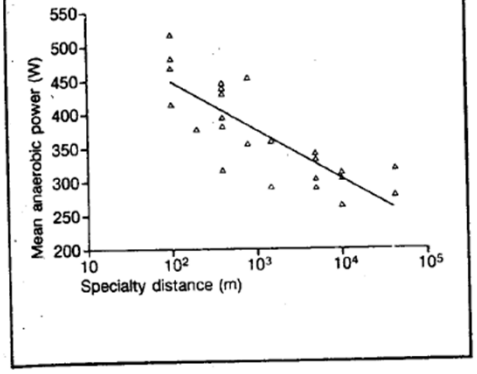


Fig. 4. Performance of the Wingate anaerobic test by runners of various specialties. Individual data of 24 male members of the Burmese National track team are plotted against the log of their running specialty (ranging from 100m to a marathon). $r_{sp} = 0.82$.

Wingate Compared to Other Anaerobic Tests

Table V. Correlation between Wingate anaerobic test (WAT) scores and other laboratory anaerobic indices

WAT index	No.	Laboratory test or index	r	Reference
PP	15	Margaria step-running	0.79	Ayalon et al. (1974)
PP/kg	11	Margaria step-running	0.84	Jacobs (1979)
PP/kg	15	Margaria step-running	−0.003	Taunton et al. (1981)
PP	19	PP – Thorstensson isokinetic	0.61	Inbar et al. (1981)
MP	19	MP – Thorstensson isokinetic	0.78	Inbar et al. (1981)
MP	16	Maximal O_2 debt	0.86	Bar-Or et al. (1977)
PP	11	O_2 debt post WAT	0.85	Jacobs (1979)
MP	11	O_2 debt post WAT	0.63	Jacobs (1979)
MP	14	O_2 debt post WAT	0.47	Tamayo et al. (1984)
rev/30 sec	11	Lactate post WAT	0.60	Jacobs (1979)
MP/kg	14	Lactate post WAT	0.60	Tamayo et al. (1984)
PP/LBM	19	% FT area	0.60	Bar-Or et al. (1980)
% fatigue	19	FT area/ST area	0.75	Bar-Or et al. (1980)
MP/LBM	19	FT area/ST area	0.63	Bar-Or et al. (1980)
PP	29	% FT	0.72	Inbar et al. (1981)
MP	29	% FT	0.57	Inbar et al. (1981)
PP	9	FT area	0.84	Kaczkowski et al. (1982)
MP	9	FT area	0.83	Kaczkowski et al. (1982)

Abbreviations: PP = peak power; MP = mean power; LBM = lean body mass; FT = fast twitch muscle fibre.

Calculations

- **Pk-AnP**
  - Should be expressed in Watts
  - Best to use the newton (N) unit as the expression of force (rather than kg)
    - 1 kg = 9.81 N
  - Pk-AnP ($N \cdot m \cdot sec^{-1}$; W) = (N x (Rmax x 6))/5
  - Example:
    - A person's highest 5 second interval was 12 revolutions at a force setting of 4.6 kg (45 N)
    - Pk-AnP = (45 x (12 x 6))/5 = 648 W
  - Divide Pk-AnP by the person's bodyweight (kg) to get relative Pk-AnP

Calculations

- **Total Work**
  - w (N·m; J) = N x (R x 6)
    - N = the force in Newtons
    - R = the total number of revolutions in 30 seconds
- **M-AnP**
  - M-AnP (W; $J \cdot sec^{-1}$) = total work / 30 s
  - Divide M-AnP by the person's bodyweight (kg) to get relative M-AnP
- **Fatigue Index**
  - FI (%) = ((Pk-AnP – lowest AnP) / Pk-AnP) x 100

Hand Calculations

Monark Test Report

Human Performance Research
tel. Exercise Science Program

Monark Anaerobic Test
Created: 2.11.2010 17:11:26

Person Information

First Name:	Justin	Height:	181
Last Name:	Lyons	Weight [kg]:	86
Sex:	Male	Date of Birth:	15.12.1999

Test Information

Test Duration [s]:	30	Date and Time:	10.11.2009 18:33:06
Brake Weight [kg]:	8.6	Supervisor:	
Person Weight [kg]:	86		

Analysis

Peak Power [W]:	1,177.55	Power Drop [W]:	591.49
Peak Power [W/kg]:	13.69	Power Drop [W/kg]:	6.88
Avg. Power [W]:	891.78	Power Drop [W/s]:	19.72
Avg. Power [W/kg]:	10.37	Power Drop [W/s/kg]:	0.229
Min. Power [W]:	586.06	Power Drop [%]:	50.23
Min. Power [W/kg]:	6.81		

Hand Calculations

Time [s]	W	W/kg	Rpm	
-30...-25	-	-	101	
-25...-20	-	-	98	
-20...-15	-	-	93	
-15...-10	4.72	0.05	92	
-10...-5	22.78	0.26	95	
-5...0	466.60	5.43	172	
0...5	957.26	11.13	152	12.67 REV
5...10	974.82	11.34	123	10.25 REV
10...15	911.50	10.60	111	9.25 REV
15...20	817.63	9.51	101	8.42 REV
20...25	745.24	8.67	91	7.58 REV
25...30	650.79	7.57	82	6.83 REV

Total = 55 REV

Norms

Table 2 Comparative Scores for the Wingate Bike Test

Group	F-Set	Pk-AnP	Rel-Pk-AnP	Total w	M-AnP	Rel-M-AnP
Males	%wt	W	W·kg^{-1}	kJ	W	W·kg^{-1}
Normals						
18–29 y[23]	7.5	540	8.2	13.5	450	7.0
25–34 y	7.5	700	9.2	16.2	540	7.2
35–44 y	7.5	660	8.6			
18–28 y[35]	7.5				563	7.3
Athletes[28]	7.5		11.8			
Cyclists[50]						
Category II–IV	9.5	963	13.3		783	10.8
Ice Hockey[39]	7.5			15.6		
Volleyball Olympians[49]	10.0			23.9	797	9.1
Sprinters[45]	9.0		14.2	23.9		
Nondesignated[22]	9.5	1064		25		
Females						
PE Majors[25]	~7.7	561	9.0		453	7.2
Softball Players[47]	7; 8		9.1; 9.6			
	9; 10		10.8; 11.1			

Norms

Table 3 Percentile (%ile) Norms for Pk-AnP (W) and Rel-Pk-AnP (W·kg^{-1}) for the Wingate Test in Physically Active Men (n = 62) and Women (n = 68) Ages 18–28 y

%ile Rank	Pk-Anaerobic Power (W)		Relative-Pk-AnP (W·kg^{-1})	
	Men (W)	Women (W)	Men (W·kg^{-1})	Women (W·kg^{-1})
95	867	602	11.1	9.3
90	822	560	10.9	9.0
85	807	530	10.6	8.9
80	777	527	10.4	8.8
75	768	518	10.4	8.6
70	757	505	10.2	8.5
65	744	493	10.0	8.3
60	721	480	9.8	8.1
55	706	464	9.5	7.8
50	689	449	9.2	7.6
45	678	447	9.0	7.2
40	671	432	8.9	7.0
35	662	418	8.6	7.0
30	656	399	8.5	6.9
25	646	396	8.3	6.8
20	618	376	8.2	6.6
15	594	362	7.4	6.4
10	570	353	7.1	6.0
5	530	329	6.6	5.7
M	699.5	454.5	9.18	7.61
SD	94.7	81.3	1.43	1.24
Minimum	500	239	5.3	4.6
Maximum	927	623	11.9	10.64

From P. J. Maud and B. B. Schultz, *Research Quarterly for Exercise and Sport, 60*(2), p. 147, 1989. Copyright © 1989 AAHPERD, 1900 Association Dr., Reston, VA 22091.

Norms

Table 4 Percentile (%ile) Norms for M-AnP (W) and Rel-M-AnP (W·kg^{-1}) for the Wingate Test in Physically Active Men (n = 60) and Women (n = 69) Ages 18–28 y

%ile Rank	M-Anaerobic Power (W)		Relative-M-AnP (W·kg^{-1})	
	Men (W)	Women (W)	Men (W·kg^{-1})	Women (W·kg^{-1})
95	677	483	8.63	7.5
90	662	470	8.24	7.3
85	631	437	8.09	7.1
80	618	419	8.01	7.0
75	604	414	7.96	6.9
70	600	410	7.91	6.8
65	592	402	7.70	6.7
60	577	391	7.59	6.6
55	575	386	7.46	6.5
50	565	381	7.44	6.4
45	553	377	7.26	6.2
40	548	367	7.14	6.15
35	535	361	7.08	6.13
30	530	353	7.00	6.0
25	521	347	6.79	5.9
20	496	337	6.59	5.7
15	485	320	6.39	5.6
10	471	306	5.98	5.3
5	453	287	5.56	5.1
M	562.7	381	7.28	6.35
SD	66.5	56.4	0.88	0.73
Minimum	441	235	4.6	4.5
Maximum	711	529	9.1	8.1

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Norms

Table 5 Percentiles (%ile) for Fatigue Index of the Wingate Test in Physically Active Men (n = 52) and Women (n = 50) Ages 18–28 y

%ile	Fatigue Index (%)	
	Men (%)	Women (%)
95	55	48
90	52	47
85	47	44
80	46.7	43.6
75	45	42
70	43	40
65	42	39
60	40	38
55	39	38
50	38	35
45	37	34
40	35	33.7
35	34	31
30	31	29
25	30	28
20	29.5	26
15	27	25
10	23	25
5	21	20
M	37.7	35.0
SD	9.9	8.3
Minimum	15	18
Maximum	58	49

From P. J. Maud and B. B. Schultz, *Research Quarterly for Exercise and Sport, 60*(2), p. 148, 1989. Copyright © 1989 AAHPERD, 1900 Association Dr., Reston, VA 22091

Class Laboratory Exercise

- ~~As many students as would like~~ All students who are able will perform a Wingate Anaerobic Test
- Our research question:
  - Do males and females differ with respect to the different variables assessed from a Wingate Anaerobic Test.

Data