REVIEW ARTICLE

The compatibility of running-based anaerobic sprint test and Wingate anaerobic test: a systematic review and meta-analysis

Kuldeep Nara[ABCDE], Parveen Kumar[ABCD], Rohit Rathee[1BD], Jitender Kumar[ABC]

Department of Physical Education, Chaudhary Ranbir Singh University, Jind, Haryana, India

Authors' Contribution: A - Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The objective of the study was to perform a systematic review of the literature and meta-analysis to determine the validity of running-based sprint test in relation to 30 second Wingate anaerobic test.

Material and Methods A search of the relevant literature was done using the key words, 'running-based anaerobic sprint test', 'RAST', 'Validity' 'repeated sprint' and 'Wingate'. Twelve studies including 368 participants were finalized to systematic review and meta-analysis. The mean ± standard deviation of the number of participants was 30.66 ± 16.17 years.

Results The summary of effects size were calculated to established the validity of running based sprint test (RAST) with 30 seconds Wingate test as a criterion measure. All studies indicate that effect size of Peak Power (PP) shows higher summary effects 0.58 (95%CI – 0.37, 0.79), similar outputs were observed for Mean Power (MP) 0.67 (95%CI – 0.45, 0.90). Therefore, the average outcomes were significantly different from zero.

Conclusions Running-based anaerobic sprint test is a valid alternative method of 30 seconds Wingate test to measure anaerobic power outputs of healthy individual belongs to various sports disciplines. Although, anaerobic capacity or power output is a determinant factor in power dominating sports. Therefore, RAST is compatible to laboratory-based Wingate 30 second anaerobic test (WAnT) in field-based settings.

Keywords: Sprint Test, Wingate Test, anaerobic test, validity

Introduction

The term "anaerobic" has been defined as "capable of living in the absence of air or free oxygen" (Webster 1977); when related to metabolism "anaerobic" refers to those metabolic processes which resynthesise adenosine triphosphate (ATP) and yield various end-products but do not involve the use of oxygen as a terminal substrate [1]. It is evident that the most instant source of energy production during muscular contraction is the anaerobic break-down of stored high-energy organic phosphate compounds (known as phosphagens) primarily adenosine triphosphate (ATP) and creatine-phosphate (CP). Repeated sprint ability can be synonymy used for the anaerobic capacity of an individual. The capability of sprint repeatedly with minimal recovery time is widely accepted as an important component of physical performance in various team sports such as basketball, handball, soccer, hockey etc. [2-4]. Maximal anaerobic power (Wmax) is an important parameter in many individual sports where explosive power is a dominant factor. Research evident that anaerobic power is significantly related with fat free mass muscle mass in body composition [5]. Anaerobic capacity/anaerobically attributable power is an important parameter for athletic performance, not only for short high-intensity activities but also for breakaway efforts and end spurts during endurance events [6]. In Skiers the contribution of anaerobic energy system was 26% and seemed independent of technique [7]. A linear regression analysis showed that there were high statistically significant correlation found between Anaerobic capacity and timing of 100m, 200m and 400m timing [8], so, the anaerobic capacity could be used as predictor of performance for these short distance speed dominant athletic events [9]. It was evident in literature that anaerobic power is a determinant factors of performance in different sports. While the assessment of anaerobic power is also an important factor as well as training to recognize the impact of intervention on anaerobic power [10, 11]. Assessment before and after an given intervention provide the effectiveness of a particular training. Accurate measurements of physical and physiological parameters provide an actual status of an athletes. The present status of an individual leads the further training needs.

The running-based anaerobic sprint test (RAST) has been developed to test anaerobic power using a repeated sprint protocol with variables that are analogous to the WAnT. The RAST involves six 35-meter sprints separated by 10 seconds of recovery. The distances and recovery time characteristic of the RAST protocol suggest that it might be an ideal test

doi:10.15561/26649837.2022.0208

to evaluate the RSA (repeated sprint ability) of field-based team sport athletes. Previous evaluations of the RAST have examined correlations of peak power (PP), mean power (MP), and fatigue index (FI) with the WAnT [12]. Various similar test has been designed with little variation in recovery time to measure anaerobic capacity of an individual [13, 14]. The Running Anaerobic Sprint Test (RAST) was developed in 1997 by Draper and Whyte to provide a means of determining anaerobic power, which was both inexpensive and simple to implement and thus accessible to coaches for players of all levels [15]. The power produced during each sprint was determined by the following formula: Power = (Body Mass × Distance2)/ Time3 . Peak power was defined as the power obtained during the fastest sprint and average power (for all six sprints) was calculated by taking the mean values of all sprints [16]. RAST is similar to the Wingate Anaerobic 30s cycle test (WANT) in that it provides coaches with measurements of power and fatigue index [17].

The 30 seconds Wingate anaerobic test (WAnT) is a valid test for assessment of anaerobic power output [18-27]. The WAnT is a laboratory-based test which require special equipment, such as computer-based cycle ergometer with mechanically braking system, desktops or big screens to display and much more device for articulation to each device. While, running based sprint test is a similar field-based test to measure anaerobic power output of an athlete. Therefore, the present study attempts to establish the validity and compatibility of running-based anaerobic sprint test in comparison to WAnT test.

Material and Methods

Literature Search Strategy

The systematic review of literature was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) norms and standards [28]. A systematic search of related literature was done for assessing the studies containing validity of running based anaerobic sprint test with WAnT test as criterion measure. The search includes manuscripts published between since 2000 to 2020, as well as thesis/dissertation completed and available between the selected time span. Google scholar, PubMed, Research gate, Academia, and Medline databases were searched using the terms ‘running-based anaerobic sprint test’, ‘RAST’, ‘Validity’ ‘repeated sprint’ and ‘Wingate’. Reference lists from selected studies were also reviewed.

Inclusion and Exclusion Criteria

Subjects of any age were included. Studies meeting the following standards or inclusion criteria were taken into consideration for review in the present study: (1) Studies available in English and Hindi Language (2) participants assigned by random technique from different sports. (3) Studies reported subjects’ characteristics, i.e., sample size, age, height, weight, gender, and game of the participants. (4) studies used Wingate test (WAnT) as criterion measure for assessing validity. (5) Studies reported correlation coefficient of the variables (relative to body mass) peak power (PP), and mean power (MP), between running-based anaerobic sprint test (RAST) and Wingate (WAnT) test. Studies were excluded for the following reasons: (1) studies not reported sample size (2) use different test than 30 second Wingate (WAnT) anaerobic test as criterion measure (3) animal subjects (4) patient’s subjects (5) reported different sprint test.

Study Selection

A search of various e-databases with pre-defined key words including scan of reference list revealed 716 relevant studies between 2000 to 2020, a review of 20 years’ studies taking into consideration. Based on title, or abstract or lack of relevant data structure 675 studies were excluded from the meta-analysis. Forty-one full text articles were evaluated, and 12 were included for the meta-analysis (see fig.1). Each study was deeply analyzed and coded for descriptive variables: body composition of Subjects (age, height, weight, gender and game of participants), sample size, running based anaerobic sprint test characteristics (no. of sprints, length of sprint, and recovery time). The studies conducted RAST and WAnT through proper guideline and protocols included in the present study for meta-analysis.

Data Collection

Anaerobic power data were extracted in the forms of dependent variables peak power (PP), and mean power (MP), reported in terms of mean of relative to body mass . Sample size and Correlation coefficient between running-based sprint test and Wingate test were also extracted for further computation of summary effect.

Study Characteristics

Twelve studies (see table 1) were collected through systematic literature review (SLR) contain 368 participants. The number of participants was 30.66±16.89 (mean±sd). Participant’s age was 19.45±4.52 years. The average height of the participants was 173.84±10.58 centimetres, while body mass was 66.83±10.64 kilograms. The participants were enrolled in following sports i.e., soccer, basketball, hockey, cycling, football, sprint events, middle distance runners, volleyball with 3 to 5 years of playing experience reported in studies. Nine effects involved studies of men only; two studies [29, 30] included both men and women. Two studies contain little variation in administration & procedure of running-based anaerobic sprint test including 8 sprints of 40 meters [31] and 6 sprints of 15 meters [29] as well. Rest of studies include 6 sprints of 35 meters with 10 seconds recovery time between each sprint. All studies included in

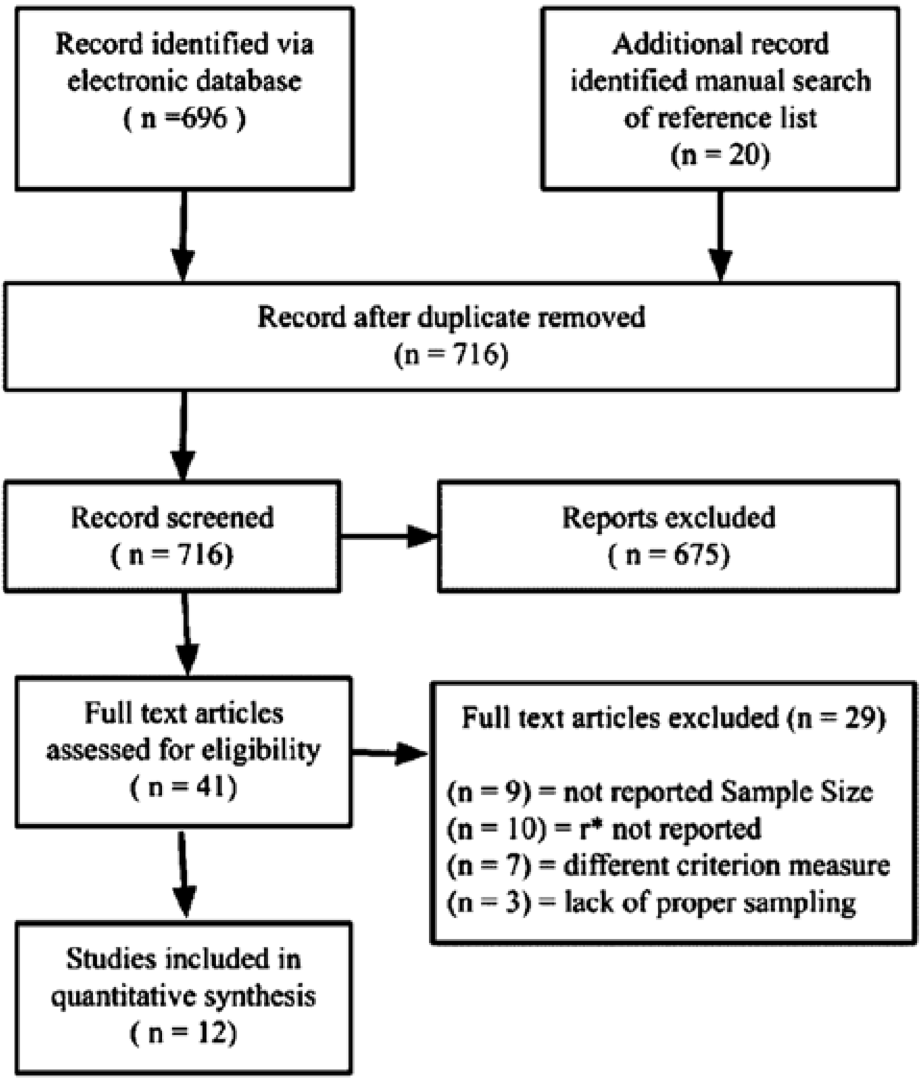

Fig. 1. Flow Chart of the Study Selection

meta-analysis were methodologically sound and met the assumptions of meta-analysis procedure. Mean values of outputs, i.e., Peak Power (PP), Mean Power (MP) and Fatigue Index were only reported by four studies [12, 30, 32, 33]. Eight studies were not reported mean values of pre-defined parameters. The studies included in meta-analysis were conducted on the following countries i.e., United Kingdom (1), India (2), Singapore (1), Canada (1), Turkey (1), South America (3), Poland (1), Germany (1) and Tunisia (1) respectively.

Meta-Analysis

summary effects were carried out using the correlation coefficient (see table 2) as the outcomes measure. A random effects model was fitted to the data [39]. Random effects model was applied because of variation in several factors (e.g., participants characteristics across studies, variation in number of participants among studies, nature of sports, length of recovery time in RAST, number of sprints). The amount of heterogeneity was estimated using the DerSemonian-Laired estimator [40]. In addition to the estimate of tau2, the Q-test for heterogeneity and I2 were used [41].

Data Synthesis and Analysis

Using Jamovi 2.2.5 with a module of MAJOR (meta-analysis for Jamovi 1.2.1- an interface for jamovi and the r package *'Metafor'*, an overall summary effects of correlation coefficient, associated 95% confidence interval were calculated [42]. Further, Meta-Essential workbook version 1.4 developed by Henk ven Rhee, Robert Suurmond and Tony Halk. The workbooks were licensed under the Creative Commons Attribution-Non-Commercial-ShareAlike 4.0 International License. The meta-essential workbook was specially used to estimate

Table 1. Characteristics of the Studies examining the validity of running-based anaerobic sprint test in context of Wingate (WAnT) test as a criterion measure

Study	Sample Size	Sex	Game	Age	Height	Weight	No. of Sprint
(Rashid Aziz & Chuan Teh, 2004)[31]	26	M	Hockey, Soccer	21.80	171.10	61.30	8×40
(Zagatto et al., 2009)[34]	11	M	Middle Distance Running	21.00	171.00	66.30	6×35
(Adamczyk, 2011)[30]	37	M/F	Sprint	18.70	182.70	72.30	6×35
Haj-Sassi et al., 2011)[35]	27	M	Athletics	20.60	176.00	68.20	NR*
(Zagatto et al., 2012)[36]	40	M	Volleyball, Soccer, Basketball, Athletic	19.78	176.00	70.34	6×35
(Queiroga et al., 2013)[32]	10	M	Cyclist	28.00	172.00	70.60	6×35
(Keir et al., 2013)[12]	8	M	Soccer	20.80	175.90	74.60	6×35
(Bongers et al., 2015)[29]	65	M/F	Basketball	10.00	143.00	36.00	6×15
(Reddy et al., 2015)[37]	45	M	Basketball	16.46	182.00	72.20	6×35
(Burgess et al., 2016)[16]	23	M	Soccer	24.00	180.00	75.40	6×35
(Hazir et al., 2018)[33]	31	M	Soccer	15.90	174.40	62.70	6×35
(Singh, 2019)[38]	45	M	Football	16.46	182.00	72.02	6×35

M = male participant, F = Female *participants*, NR = not reported

Table 2. Correlation of coefficient between running-based anaerobic sprint test (RAST) and Wingate test (WAnt)

Study	PP (r)	ES	(95% CI)	MP (r)	ES	(95% CI)
(Rashid Aziz & Chuan Teh, 2004)	0.63	0.74	(0.33, 1.15)	0.46	0.50	(0.09, 0.91)
(Zagatto et al., 2009)	0.46	0.50	(0.18, 0.82)	0.53	0.59	(0.27, 0.91)
(Adamczyk, 2011)	0.69	0.85	(0.51, 1.18)	0.55	0.62	(0.28, 0.95)
Haj-Sassi et al., 2011)	0.51	0.56	(0.16, 0.96)	0.77	1.02	(0.62, 1.42)
(Zagatto et al., 2012)	0.41	0.44	(-0.26, 1.13)	0.25	0.26	(-0.44, 0.95)
(Queiroga et al., 2013)	0.10	0.10	(-0.64, 0.84)	0.54	0.60	(-0.14, 1.34)
(Keir et al., 2013)	0.21	0.21	(-0.66, 1.09)	0.38	0.40	(-0.48, 1.28)
(Bongers et al., 2015)	0.86	1.29	(1.04, 1.54)	0.91	1.53	(1.28,1.78)
(Reddy et al., 2015)	0.31	0.32	(0.02, 0.62)	0.54	0.60	(0.30, 0.91)
(Burgess et al., 2016)	0.70	0.87	(0.43, 1.31)	0.60	0.69	(0.25, 1.13)
(Hazir et al., 2018)	0.25	0.26	(-0.11, 0.63)	0.22	0.22	(-0.15, 0.59)
(Singh, 2019)	0.31	0.32	(0.02, 0.62)	0.54	0.60	(0.30, 0.91)

PP = Peak Power Output, MP = Mean Power Output, ES = Effect Size, CI = Confidence Interval, r = correlation coefficient

the moderator analysis. The analysis was carried out using the correlation coefficient (see table 2) as the outcome measure. A random-effects model was fitted to the data. The amount of heterogeneity (i.e., tau^2), was estimated using the was estimated using the restricted maximum-likelihood estimator [43]. Distribution of true outcomes was determined to be heterogeneous is Q reached a significance level of P<0.05 and the sampling error accounted for less than 75% of the observed variance. An I2 statistics was also calculated to assess heterogeneity of effects. In case of any heterogeneity was detected (i.e., tau2 > 0, regardless of the results of the Q-test), prediction interval for the true outcomes was also provided. A fail-safe number was calculated to determine the number of unpublished studies of null findings necessary to negate the significant true outcomes or to address publication bias. Studentized residuals and Cook's distances are used to examine whether studies may be outliers and/ or influential in the context of the model. Studies with a studentized residual larger than the 100 × [1 - 0.05/ (2 × n)]th percentile of a standard normal distribution are considered potential outliers (i.e., using a Bonferroni correction with two-sided alpha = 0.05 for n studies included in the meta-analysis). Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances are considered to be influential. The rank correlation test and the regression test, using the standard error of the observed outcomes as predictor, are used to check for funnel plot asymmetry [44].

Moderator Analysis

Three potential moderators were selected a priori based on their theoretical or empirical relation which leads to changes or variation in outputs of running-based anaerobic sprint test: age, standing height, and weight. Simple linear regression was used to compute the regression coefficient(β) of the slope, which is an estimate of the association between the moderator and a study's effect size.

Results

Peak Power Analysis

A total of k=12 studies were included in the analysis. The observed Fisher r-to-z transformed correlation coefficients ranged from 0.1003 to 1.2933, with the majority of estimates being positive (100%). The estimated average Fisher r-to-z transformed correlation coefficient based on the random-effects model was \hat{\mu} = 0.5826 (95% CI: 0.3710 to 0.7943). Therefore, the average outcome differed significantly from zero ($z = 5.3948$, $p < 0.0001$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(11) = 46.0854$, $p < 0.0001$, $tau^2 = 0.0912$, $I^2 = 70.9600\%$). A 95% prediction interval for the true outcomes is given by -0.0458 to 1.2111. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study [29] had a value larger than ± 2.8653 and may be a potential outlier in the context of this model. According to the Cook's distances, one study [29] could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot (see fig. 3a, fig. 3b) asymmetry ($p = 0.9451$ and $p = 0.1657$, respectively).

Mean Power Analysis

A total of k=12 studies were included in the analysis. The observed Fisher r-to-z transformed correlation coefficients ranged from 0.2237 to 1.5275, with the majority of estimates being positive (100%). The estimated average Fisher r-to-z transformed correlation coefficient based on the random-effects model was \hat{\mu} = 0.6736 (95% CI: 0.4491 to 0.8981). Therefore, the average outcome differed significantly from zero ($z = 5.8812$, $p < 0.0001$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(11) = 54.5253$, $p < 0.0001$, $tau^2 = 0.1076$, $I^2 = 74.2488\%$). A 95% prediction interval for the true outcomes is given by -0.0073 to 1.3544. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study [29] had a value larger than ± 2.8653 and may be a potential outlier in the context of this model. According to the Cook's distances, one study [29] could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p = 0.7305$ and $p = 0.1747$, respectively).

Moderator Analysis

Three potential moderators were recognized i.e., age, height and weight of the respondents. A moderator analysis was done in meta-essential software for the selected moderators. A simple linear weighted regression was run with the moderator as a predictor of the effects size of the study. In Meta-Essentials, it is not possible to run a multivariate regression analysis, so only one moderator was assessed at a time. The mean and standard deviation of age distribution of respondents was 19.45±4.52 years (95% CI: 16.89 – 22.01). The beta coefficient of age as a moderator was not statistically significant ($\beta = -0.33$, $z = -1.04$, $P > 0.05$), indicating no significant effects on effect size of study. The mean and standard deviation of height of respondents was 173.84±10.59 centimeters (95% CI: 167.85 – 179.83). The beta coefficient of height as a moderator was not statistically significant ($\beta = -0.33$, $z = -0.97$, $P > 0.05$), indicating no significant effects on effect size of study. The mean and standard deviation of weight of respondents was 66.83±10.64 kilogram (95% CI: 60.80 – 72.85). The beta coefficient of weight as a moderator was also not statistically significant ($\beta = -0.38$, $z = -1.14$, $P > 0.05$), indicating no significant effects on effect size of study. Effects were not significantly varied when moderating by age, height and weight of the respondents of the studies.

Discussion

The aggregated findings indicated that running based anaerobic sprint test (RAST) is valid (summary effects = 0.58 to 0.67) and effective means to measure anaerobic capacity in field settings. It is a valid alternative method of laboratory-based Wingate 30 second anaerobic test. The correlation coefficient of the studies in relation to peak power output were ranged from 0.10 to 0.86, and mean power output was 0.22 to 0.91 according to selected studies in meta-analysis. It is evident that anaerobic capacity play an important role in short-duration activities [45]. Its use is supported by; (a) the high correlations observed between maximal blood lactate and short-duration exercise performance presumably dependent upon anaerobic capacity, and (b) the

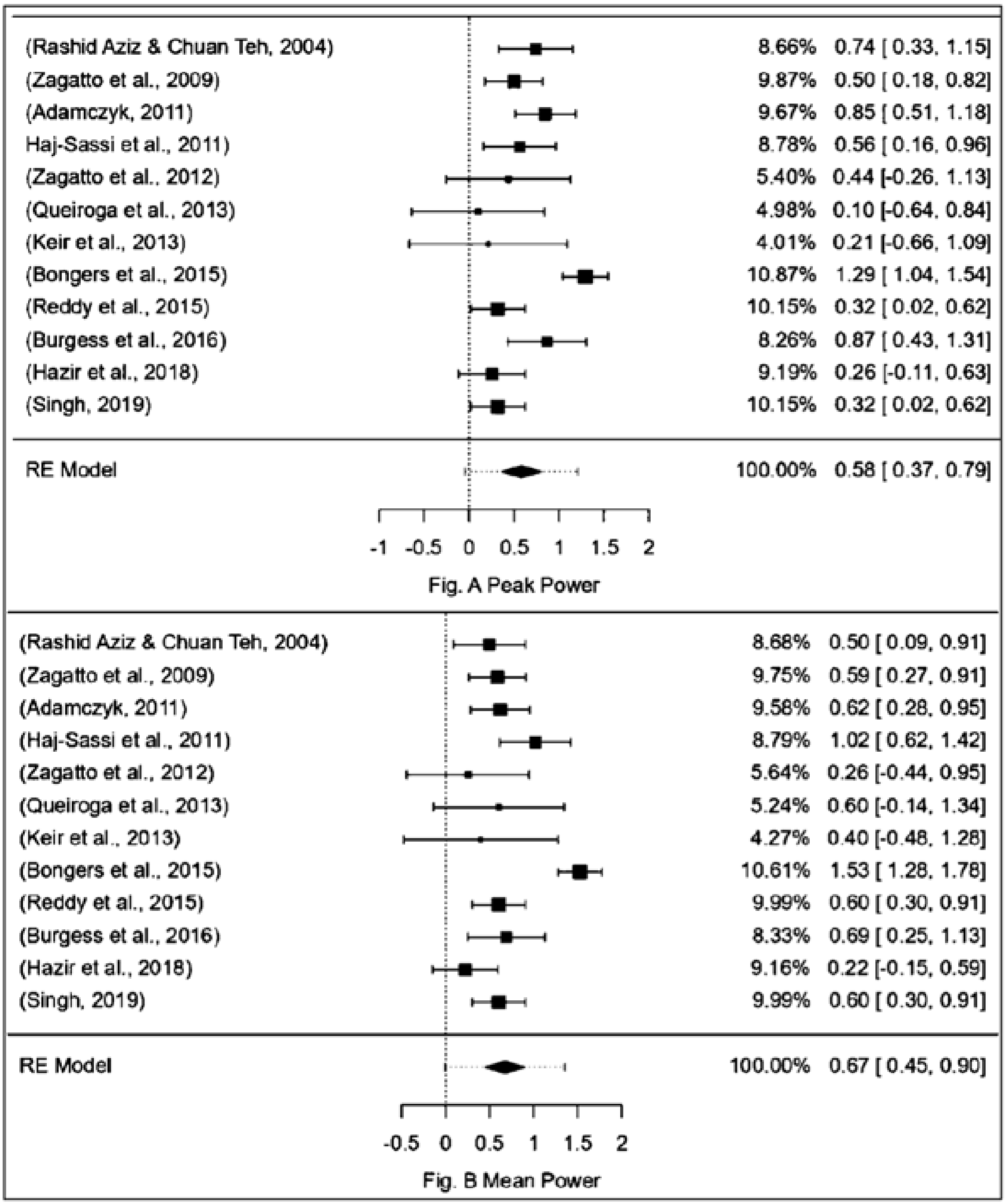

Figure 2. Forest plot of coefficient of correlation corresponding summery estimate (RE Model), modal fitting weights with 95% confidence interval and prediction interval (a) peak power PP (b) mean power, MP. The estimated correlation coefficient is based on random effects model.

higher maximal blood lactate values observed in sprint and power athletes (who would demonstrate higher anaerobic capacities) compared with endurance athletes or untrained people [46]. In some prospective studies, [47-50] a significant relationship (r = 0.88) was observed between anaerobic capacity and VO2max of cross-country runners and elite long distance runners. Anaerobic capacity is associated with developmental coordination disorder (DCD). The mean score of anaerobic measures (peak power & mean power) were significantly lower in children with DCD [51]. Anaerobic capacity is associated with body composition parameters also. A regression model developed by Durkalec-Michalski et.al. showed that BM (body mass) and FFM (fat free mass) significantly contributed to the prediction of VO2max and AP (anaerobic power) [52]. Anaerobic power is positively related to preponderance and size of muscle fibers types. Average power output is related to relative fiber size (average FT area/ average ST area); peak power, to % FT and to % FT area; and the power decrease to relative fiber size

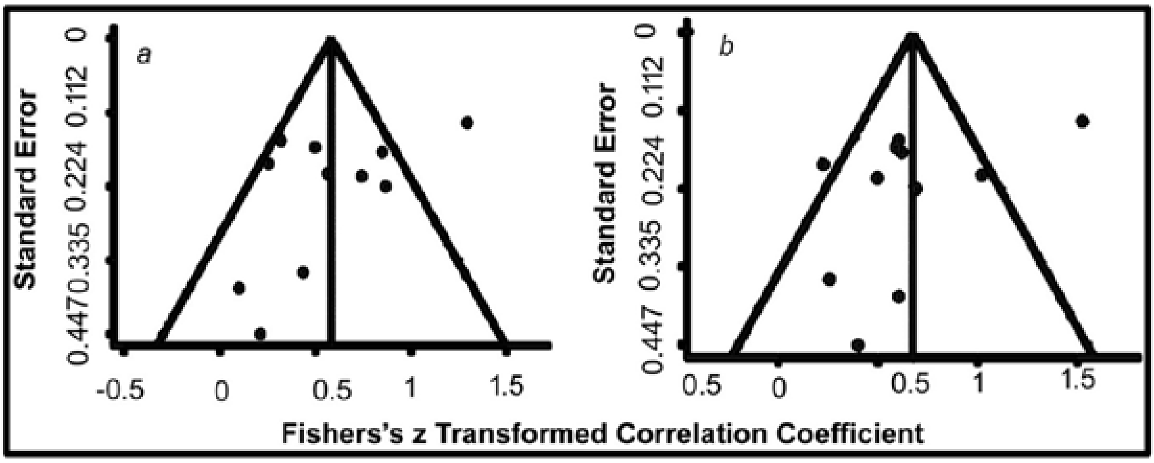

Figure 3. Funnel Plot of fisher's z transformed correlation coefficient versus study sample size (standard error) (a) Peak Power, (b) Mean Power.

[53]. Although, heritability is a determining factor for muscle fiber types associated with anaerobic capacity [54], the aerobic capacity could be increased through various trainings methods.

Although, there are several factors associated with maximal anaerobic power during the RAST test, for instance, motivation, surface, atmosphere, time of the test, recovery condition of athletes etc. Therefore, before the administration of the test examiner needs to consider the above factors into consideration to obtain reliable outcome.

Conclusions

This systematic review and meta-analysis revealed that running-based anaerobic sprint test (RAST) is a valid method to assess anaerobic capacity of an individual belongs to various age groups. Moderate to high degree of effects size (ES) or summary effects were observed in context of selected measures, i.e., peak power (PP) and mean power (MP). Relative to 30 second Wingate anaerobic test, RAST present an equally effective with a much lower cost of conduct and easy to administrate in field settings. Human performance laboratories are very expensive and not easy to operate for everyone. In this situation, coaches and trainers need an assessment tool which is equally effective as a laboratory test and easy to administrate.

References

1. Green S. A definition and systems view of anaerobic capacity. *European Applied Physiology and Occupational Physiology,* 1994;69:168–73. https://doi.org/10.1007/BF00609411
2. di Mascio M, Ade J, Bradley PS. The reliability, validity and sensitivity of a novel soccer-specific reactive repeated-sprint test (RRST). *European Journal of Applied Physiology*, 2015;115(12):2531–42. https://doi.org/10.1007/s00421-015-3247-0
3. Bishop D, Spencer M, Duffield R, Lawrence S. The Validity of a Repeated Sprint Ability Test. *Journal of Science and Medicine in Sport* 2001;4(1):19–29. https://doi.org/10.1016/S1440-2440(01)80004-9
4. Gharbi Z, Dardouri W, Haj-Sassi R, Chamari K, Souissi N. Aerobic and anaerobic determinants of repeated sprint ability in team sports athletes. *Biology of Sport*, 2015;32(3):207–12. https://doi.org/10.5604/20831862.1150302
5. Kim J, Cho H-C, Jung H-S, Yoon J-D. Influence of Performance Level on Anaerobic Power and Body Composition In Elite Male Judoists. *Journal of Strength and Conditioning Research,* 2011;25(5):1346–54. https://doi.org/10.1519/JSC.0b013e3181d6d97c
6. Noordhof DA, Skiba PF, de Koning JJ. Determining Anaerobic Capacity in Sporting Activities. *International Journal of Sports Physiology and Performance*, 2013;8(5):475–82. https://doi.org/10.1123/ijspp.8.5.475
7. Losnegard T, Myklebust H, Hallén J. Anaerobic capacity as a determinant of performance in sprint skiing. *Medicine and Science in Sports and Exercise*, 2012;44(4):673–81. https://doi.org/10.1249/MSS.0b013e3182388684
8. Katch VL, Weltman A. Interrelationship between anaerobic power output, anaerobic capacity and aerobic power. *Ergonomics*, 1979;22(3):325–32. https://doi.org/10.1080/00140137908924616
9. Smirniotoy A, Karatzanos E. Correlation of the running-based anaerobic sprint test (RAST) and performance on the 100M, 200M and 400M distance tests. *Journal of Human Movement studies*, 2005;49:77–92.
10. Spencer M, Fitzsimons M, Dawson B, Bishop D, Goodman C. Reliability of a repeated-sprint test for field-hockey. *Journal of Science and Medicine in Sport*, 2006;9(1):181–184. https://doi.org/10.1016/j.jsams.2005.05.001
11. Wragg CB, Maxwell NS, Doust JH. Evaluation of the reliability and validity of a soccer-specific

field test of repeated sprint ability. *European Journal of Applied Physiology*, 2000;83(1):77–83. https://doi.org/10.1007/s004210000246

12. Keir DA, Riault FT, Serresse O. Evaluation of the Running-Based Anaerobic Sprint Test as a Measure of Repeated Sprint Ability in Collegiate-Level Soccer Players. *Journal of Strength and Conditioning Research*, 2013;27(6):1671–8. https://doi.org/10.1519/JSC.0b013e31827367ba
13. Castagna C, Lorenzo F, Krustrup P, Fernandes-Da-Silva J, Póvoas SCA, Bernardini A, et al. Reliability characteristics and applicability of a repeated sprint ability test in young Male soccer players. *Journal of Strength and Conditioning Research*, 2018;32(6):1538–44. https://doi.org/10.1519/JSC.0000000000002031
14. Hendrik Madou K, Pribish C. Introduction, interpretation and reliability of a simple wingate based modified field running test to assess anaerobic capacity (of female soccer players in Germany and the United States of America). *MOJ Sports Med.* 2020;4(2):43–51.
15. Draper PN, Whyte G. Anaerobic performance testing. *Peak Perform*. 1997;3(5).:34-40.
16. Burgess K, Holt T, Munro S, Swinton P. Reliability and validity of the running anaerobic sprint test (RAST) in soccer players. *Journal of Trainology*, 2016; 5:24–9. https://doi.org/10.17338/trainology.5.2_24
17. Mackenzie B. *101 Performance Evaluation Tests*. London: Electric Word; 2005.
18. Legaz-Arrese A, Munguía-Izquierdo D, Carranza-García LE, Torres-Dávila CG. Validity of the Wingate anaerobic test for the evaluation of elite runners. *The Journal of Strength & Conditioning Research*, 2011;25(3):819–24. https://doi.org/10.1519/JSC.0b013e3181c1fa71
19. Bar-Or O. The Wingate anaerobic test an update on methodology, reliability and validity. *Sports Medicine*, 1987;4(6):381–94. https://doi.org/10.2165/00007256-198704060-00001
20. Dotan R. The Wingate anaerobic test's past and future and the compatibility of mechanically versus electro-magnetically braked cycle-ergometers. *European Journal of Applied Physiology*, 2006;98(1):113–6. https://doi.org/10.1007/s00421-006-0251-4
21. Dotan R, Bar-Or O. Load optimization for the Wingate anaerobic test. *European Journal of Applied Physiology and Occupational Physiology*. 1983;51(3):409–17. https://doi.org/10.1007/BF00429077
22. Barfield J-P, Sells PD, Rowe DA, Hannigan-Downs K. Practice effect of the Wingate anaerobic test. *Journal of Strength and Conditioning Research*, 2002;16(3):472–3. https://doi.org/10.1519/00124278-200208000-00022
23. Maud PJ, Shultz BB. Norms for the Wingate anaerobic test with comparison to another similar test. *Research Quarterly for Exercise and Sport*, 1989;60(2):144–51. https://doi.org/10.1080/02701367.1989.10607429
24. Beneke R, Pollmann CH, Bleif I, Leithäuser R, Hütler M. How anaerobic is the Wingate Anaerobic Test for humans? *European Journal of Applied Physiology*, 2002;87(4):388–92. https://doi.org/10.1007/s00421-002-0622-4
25. Coso J del, Mora-Rodríguez R. Validity of cycling peak power as measured by a short-sprint test versus the Wingate anaerobic test. *Applied Physiology, Nutrition, and Metabolism*. 2006;31(3):186–9. https://doi.org/10.1139/h05-026
26. Armstrong N, Welsman JR, Kirby BJ. Performance on the Wingate anaerobic test and maturation. *Pediatric Exercise Science*, 1997;9(3):253–61. https://doi.org/10.1123/pes.9.3.253
27. Coppin E, Heath EM, Bressel E, Wagner DR. Wingate anaerobic test reference values for male power athletes. *International Journal of Sports Physiology and Performance*, 2012;7(3):232–6. https://doi.org/10.1123/ijspp.7.3.232
28. Moher D, Liberati A, Tetzlaff J, Altman DG, Altman D, Antes G, et al. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 2009;6(7):1–6. https://doi.org/10.1371/journal.pmed.1000097
29. Bongers BC, Werkman MS, Blokland D, Eijsermans MJC, van der Torre P, Bartels B, et al. Validity of the pediatric running-based anaerobic sprint test to determine anaerobic performance in healthy children. *Pediatric Exercise Science*, 2015;27(2):268–76. https://doi.org/10.1123/pes.2014-0078
30. Adamczyk J. The Estimation of the RAST Test Usefulness in Monitoring the Anaerobic Capacity of Sprinters in Athletics. *PJST*. 2011;18(3):214–8. https://doi.org/10.2478/v10197-011-0017-3
31. Rashid Aziz A, Chuan Teh K. Correlation between tests of running repeated sprint ability and anaerobic capacity by Wingate cycling in multi-sprint sports athletes Stair-climbing in Singapore View project Ramadan View project. International *Journal of Applied Sports Sciences*, 2004;16(1):14–22.
32. Roberto Queiroga M, Gustavo Cavazzotto T, Yukari Katayama Bruno Sérgio Portela Marcus Peikriszwili Tartaruga Sandra Aires Ferreira K. Validity of the RAST for evaluating anaerobic power performance as compared to Wingate test in cycling athletes. *Motriz Journal of Physical Education*, 2013;19(4):696–702. https://doi.org/10.1590/S1980-65742013000400005
33. Hazir T, Kose MG, Kin-Isler A. The validity of Running Anaerobic Sprint Test to assess anaerobic power in young soccer players. *Isokinetics and Exercise Science*, 2018;26(3):201–9. https://doi.org/10.3233/IES-182117
34. Zagatto AM, Beck WR, Gobatto CA. Validity of the Running Anaerobic Sprint Test for Assessing Anaerobic Power and Perdicting Short-Distance Performance. *Journal of Strength and Conditioning Research*, 2009;23(6):1820–7. https://doi.org/10.1519/JSC.0b013e3181b3df32
35. Haj-Sassi R, Dardouri W, Gharbi Z, Chaouachi A, Mansour H, Rabhi A, et al. Reliability and Validity of a New Repeated Agility Test as a Measure of Anaerobic and Explosive Power. *Journal of Strength and COnditioning Research*, 2011;25(2):472–80. https://doi.org/10.1519/JSC.0b013e3182018186

36. Zagatto AM, Gomes EB, Loures JP. Can the Running-Based Anaerobic Sprint Test be used to Predict Anaerobic Capacity? deficiência View project Sensor Fusion for performance monitoring in sports View project. *Article in Journal of Exercise Physiology Online*, 2012;15(2):90–9.
37. Reddy Pv, DrKaukab Azeem I, Arabia YEmmanuel Kumar SS, DrQuadri Syed Javeed I, Babu D, JPrabhakar Rao I, et al. The validity of between Wingate test and Running-based Anaerobic Sprint Test (RAST) in young elite basketball players. *International Journal of Health, Education and Computer Science in Sports*, 2015;4(1):68–70.
38. Singh H. A comparative study of the validity of between Wingate test and running-based anaerobic sprint test (RAST) in young elite football players. *International Journal of Yogic, Human Movement and Sports Sciences*, 2019;4(1):1019–23.
39. Suurmond R, van Rhee H, Hak T. Introduction, comparison, and validation of Meta-Essentials: A free and simple tool for meta-analysis. *Research Synthesis Methods*, 2017;8(4):537–53. https://doi.org/10.1002/jrsm.1260
40. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Controlled Clinical Trials*, 1986;7(3):177–88. https://doi.org/10.1016/0197-2456(86)90046-2
41. Huedo-Medina T, Sanchez-Meca J, Marin-Martinez F, Botella J. Assessing heterogeneity in meta-analysis: Q statisticor I2 index? *Psychological Methods*, 2006;11(2):193. https://doi.org/10.1037/1082-989X.11.2.193
42. Viechtbauer W. Conducting Meta-Analyses in R with the metafor Package. *Journal of Statistical Software*, 2010;36(3):1–48. https://doi.org/10.18637/jss.v036.i03
43. Viechtbauer W. Bias and efficiency of meta-analytic variance estimators in the random-effects model. *Journal of Educational and Behavioral Statistics*, 2005;30(3):261–93. https://doi.org/10.3102/10769986030003261
44. Viechtbauer W, Cheung MW-L. Outlier and influence diagnostics for meta-analysis. *Research Synthesis Methods*, 2010;1(2):112–25. https://doi.org/10.1002/jrsm.11
45. Noordhof DA, Skiba PF, de Koning JJ. Determining anaerobic capacity in sporting activities. *International Journal of Sports Physiology and Performance*, 2013;8(5):475–82. https://doi.org/10.1123/ijspp.8.5.475
46. Green S, Dawson B. Measurement of Anaerobic Capacities in Humans Definitions, Limitations and Unsolved Problems. *Sports Medicine*, 1993;15(5):312–27. https://doi.org/10.2165/00007256-199315050-00003
47. Mayers N, Gutin B. Physiological characteristics of elite prepubertal cross-country runners. *Medicine and Science in Sports*, 1979;11(2):172–6.
48. Legaz-Arrese A, Munguía-Izquierdo D, Carranza-García LE, Torres-Dávila CG. Validity of the Wingate anaerobic test for the evaluation of elite runners. *The Journal of Strength & Conditioning Research*, 2011;25(3):819–24. https://doi.org/10.1519/JSC.0b013e3181c1fa71
49. Friedmann B, Frese F, Menold E, Bärtsch P. Effects of acute moderate hypoxia on anaerobic capacity in endurance-trained runners. *European Journal of Applied Physiology*, 2007;101(1):67–73. https://doi.org/10.1007/s00421-007-0473-0
50. Schnabel A, Kindermann W. Assessment of anaerobic capacity in runners. *European Journal of Applied Physiology and Occupational Physiology*, 1983;52(1):42–6. https://doi.org/10.1007/BF00429023
51. Aertssen WFM, Ferguson GD, Smits-Engelsman BCM. Performance on Functional Strength Measurement and Muscle Power Sprint Test confirm poor anaerobic capacity in children with Developmental Coordination Disorder. *Research in Developmental Disabilities*, 2016;59:115–26. https://doi.org/10.1016/j.ridd.2016.08.002
52. Durkalec-Michalski K, Nowaczyk PM, Podgórski T, Kusy K, Osiński W, Jeszka J. Relationship between body composition and the level of aerobic and anaerobic capacity in highly trained male rowers. *The Journal of Sports Medicine and Physical Fitness*, 2019;59(9):1526–35. https://doi.org/10.23736/S0022-4707.19.08951-5
53. Bar-Or O, Dotan R, Inbar O, Rothstein A, Karlsson J, Tesch P. Anaerobic capacity and muscle fiber type distribution in man. *International Journal of Sports Medicine*, 1980;1(02):82–5. https://doi.org/10.1055/s-2008-1034636
54. Calvo M, Rodas G, Vallejo M, Estruch A, Arcas A, Javierre C, et al. Heritability of explosive power and anaerobic capacity in humans. *European Journal of Applied Physiology*, 2002;86(3):218–25. https://doi.org/10.1007/s004210100522

Information about the authors:

Kuldeep Nara; https://orcid.org/0000-0002-2722-8350; kuldeepnara@crsu.ac.in; Department of Physical Education, Chaudhary Ranbir Singh University; Jind, Haryana, India.

Parveen Kumar; (Author for correspondence); http://orcid.org/0000-0002-3580-7854; parveenkumar@crsu.ac.in; Department of Physical Education, Chaudhary Ranbir Singh University; Jind, Haryana, India.

Rohit Rathee; http://orcid.org/0000-0002-3729-7384; rohit@crsu.ac.in; Department of Physical Education, Chaudhary Ranbir Singh University; Jind, Haryana, India.

Jitender Kumar; https://orcid.org/0000-0001-9898-4260; jitenderkumar@crsu.ac.in; Department of Physical Education, Chaudhary Ranbir Singh University; Jind, Haryana, India.

Cite this article as:
Nara K, Kumar P, Rathee R, Kumar J. The compatibility of running-based anaerobic sprint test and Wingate anaerobic test: a systematic review and meta-analysis. *Pedagogy of Physical Culture and Sports,* 2022;26(2):134–143.
https://doi.org/10.15561/26649837.2022.0208

Received: 11.02.2022

Accepted: 25.04.2022; **Published**: 30.04.2022