*Original research papers*

# ALTERNATIVE METHODS FOR ANAEROBIC POWER ASSESSMENT IN ATHLETES: A CORRELATIONAL STUDY OF WINGATE, VERTICAL JUMP, AND STANDING BROAD JUMP TESTS

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**Abstract**
*Introduction.* Power plays a vital role in various sporting activities in which the aerobic system produces the most energy. However, anaerobic power is vital when the player demands an immediate energy supply. The primary goal of this study is to determine whether the standing broad jump (SBJ) and vertical jump (VJ) tests can be correlated with those of the Wingate ergometry test so that a reliable and cost-effective method for athlete monitoring and skill identification is available.
*Material and Methods.* Forty healthy athletes, 26 males and 14 females from different sports, participated in the study. Each participant completed the Wingate, SBJ, and VJ tests in a controlled environment, and the results were analyzed.
*Results.* Pearson's correlation test showed a positive correlation between peak power and the SBJ distance (r = 0.74, p < 0.001) and vertical jump height (r = 0.76, p < 0.001). *Conclusions.* VJ and SBJ tests can be used as alternative tests for assessing anaerobic capabilities, injury prevention, and pre-competition screening.

**Key words:** Monark cycle ergometer, vertical jump, relative peak power, standing broad jump

## Introduction

The product of force and velocity is power. Power can be expressed as an average value throughout a range of motion or as an instantaneous value that occurs at a specific point during an object's displacement. The aerobic system produces the most energy in different sports; however, anaerobic power is also vital when a player demands an immediate energy supply [1]. Normally, this translates to approximately three times the steady--state oxidation power [2]. Sports requiring anaerobic power include football, handball, taekwondo, kabaddi, 100 m sprint, etc. Developing good conditioning programs based on the specific physiological demands of each sport is a crucial factor for its success. Anaerobic activity is energy expenditure that uses anaerobic metabolism (without oxygen) and lasts less than 90 s, utilizing exhaustive effort. Two primary energy sources are required during the Wingate anaerobic test. The first is the adenosine triphosphate-phosphocreatine (ATP-PCr) system, which lasts for 3-15 s during maximum effort. The second system is anaerobic glycolysis, sustained for the remainder of the process. Therefore, the Wingate anaerobic test measures muscles' ability to work using the ATP-PCr and glycolytic systems.

ATP is produced by the anaerobic catabolism of carbohydrates (i.e., glycogenolysis/glycolysis) and hydrolysis of high-energy phosphagens (e.g., phosphocreatine and adenine nucleotides). The total amount of ATP regenerated through the alactic capacity is defined as the hydrolysis during activity. Lactate is the main component of the entire quantity of ATP resynthesized via this pathway, known as the lactic capacity, and it accounts for 90 percent of all end products created via anaerobic carbo-hydrate catabolism [3]. Anaerobic capacity is the sum of these two capacities. The lack of interest in anaerobic performance as a component of health and fitness has led to the development of new anaerobic tests.

Anaerobic power training is important for athletes to move faster and more powerfully within a shorter duration. The Wingate anaerobic test is a valid and reliable measure of anaerobic power [4]. These tests are done by physical therapists, strength and conditioning professionals, and coaches, who help identify strengths and weaknesses in chart preparation and documentation. The assessment of bilateral strength asymmetry with the Jump Test is valid and reliable and has potential applications in sports medicine [5]. The Vertical jump (VJ) test has been the most used procedure. This method is simple because it requires a wall or board and chalk powder to form marks with fingertips. This test has a reliability of .93 and an objectivity of 0.93 [6].

Another standard field test to evaluate explosive leg power is the Standing broad jump (SBJ) test [7]. It is frequently used because it is easy to implement, quick, and requires no special tools. There is a direct relationship between the force generated by muscle fibers and the distance traveled. In contrast to the Wingate cycle ergometer test, this is less expensive, simpler to evaluate, and requires less equipment, making it suitable for use in the field [8].

Anaerobic power testing requires using relatively sophisticated and costly equipment (e.g., force plates and V-scopes). Most authorities do not have access to advanced movement analysis equipment. Consequently, alternative methods can be used for characterizing athletes' power capabilities [9]. Therefore, this study intends to find a correlation between the Wingate

ergometer test and the SBJ and VJ tests in the athletic population to help the population affordably assess lower limb power.

## Material and Methods

The Guru Nanak Dev University Institutional Ethics Committee, Amritsar, India, approved the study (No. 58/HG, Dated 12/1/2022). This study was conducted between June 2022 to October 2022. Participants were recruited from the Guru Nanak Dev University and Khalsa College in Amritsar, India. The sample size was calculated through G power version 3.1.9.4, where the effect size was 0.7. Forty athletes participated in the study, of whom 26 were males and 14 were females. Voluntary participation was ensured, and written consent was obtained from all participants. The participants were selected based on the following criteria: soccer players aged 18-25, no match played 72 hours before testing, and involvement in 6 months of regular training. Excluded were the participants who did not satisfy the age limit mentioned, any recent lower limb injury three months prior, musculoskeletal pain, and a history of soreness or fatigue. Before initiating data collection, their training experience was recorded, including medical history (if any) and competition records.

This study used Monark LC7 TT Novo as an aerobic cycle ergometer. The custom protocol modified Wingate test calculated anaerobic peak power and relative anaerobic peak power. A measuring tape, weighing machine, and chalk were used to measure the leap in the VJ and SBJ, and polar chest belt was used to assess the maximum heart rate. Anthropometric measurements were performed, including each athlete's height (cm) and weight (kg). Before collecting the final data, all testing procedures were performed on participants. VJ and SBJ were used to assess the explosive power of both legs. The participants were tested over two days to allow for sufficient recovery time between tests.

### Day 1: Standing broad jump test
The participants were encouraged to avoid strenuous exercise the day before performance testing. The participants performed a prescribed warm-up on the day of performance testing, which consisted of 10 min of jogging and 5 min of dynamic stretching of the muscles to prevent any muscular discomfort. Each participant took a starting position on the starting line with their feet shoulder-width apart and their legs straight. The participants were instructed to squat and cross their arms behind their bodies. Subsequently, they jumped as high as possible by extending their legs and propelling their arms forward. Leap distance was measured in centimeters.

### Vertical Jump Test
The participants were guided through an 8–10-minute dynamic warm-up consisting of squats, lunges, quads, calf stretches, and progressive jogging activities of 20 and 30 yards before the VJ test. The players chalked the tips of the fingers and stood sideways against the walls and feet on the ground. On the one hand, they reached up as high as they could and marked the wall with the tips of their fingers (M1) from a standing position; the players jumped as high as they could and marked the wall with chalk on their fingertips (M2). The therapist measured and noted the differences between M1 and M2. Each athlete performed the test three times. The therapist used the average of the three to assess players' performance.

### Day 2: Wingate test
Initially, a warm-up was performed for 10 min, after which a polar chest belt was applied to measure the maximum heart rate during the test. On the command "Start," the subject pedaled more than 60 kph without resistance. The maximum speed was reached within 3-4 seconds. Once the maximum speed was reached, an automatic load of 7.5 percent of body weight in kilograms was applied, and the participant was coaxed to continue pedaling for 30 seconds. Verbal encouragement was provided during the tests. Any attempt to conserve energy in the final second was frowned upon.

### Statistical Analysis
SPSS version 28.0 for Mac was used for all statistical analyses (IBM Inc. Chicago, IL, USA), where statistical significance p was less than 0.05. Means and standard deviations were computed as summary statistics. Pearson's correlation test was used to determine the relationship between VJ (cm), SBJ (cm), and peak power (w/kg) for all athletes. The correlation between variables was assessed by calculating the Z-score of relative peak power, SBJ, and VJ and then utilizing the Z-score for the Bland--Altman analysis.

## Results

The mean age of males was 20.96 years, and females were 20.43 years. The SBJ distance was 202.64 cm for males and 139.91 cm for females. The VJ height was 40.46 cm for males and 29.93 cm for females. The peak power of the Wingate test was 571.85 for males and 292.64 for females. On the linear regression curve, both SBJs were statistically significant (r = 0.74, p < 0.001), and VJs (r = 0.76, p < 0.001) were significantly correlated with the peak power in the Wingate test.

In the Bland-Altman plot analysis, the mean of the difference between the results of the two methods, SBJ and peak power, was (95% CI: -0.23 to +0.23) and for VJ and peak power was (95% CI: -0.22 to +0. 0.22). The upper and lower limits for SBJ were (+1.42) and (-1.42). The VJ were (+1.36) and (-1.36). The percentage of points lying outside the limit for the SBJ was 5%, and for the VJ was 2.5%.

**Table 1.** Correlation of vertical jump height, standing broad jump distance, and Wingate test peak power

| Correlations | | | |
|---|---|---|---|
| | Vertical Jump Height (cm) | Standing Broad Jump Distance (cm) | Wingate Relative Peak Power |
| Vertical Jump Height (cm) | 1 | .832** | .758** |
| Standing Broad Jump Distance (cm) | .832** | 1 | .736** |
| Wingate Relative Peak Power | .758** | .736** | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 2.** Discipline-wise summary statistics of mean, standard deviation, and level of significance value of Wingate peak power, Wingate relative peak power, vertical jump height, and standing broad jump distance

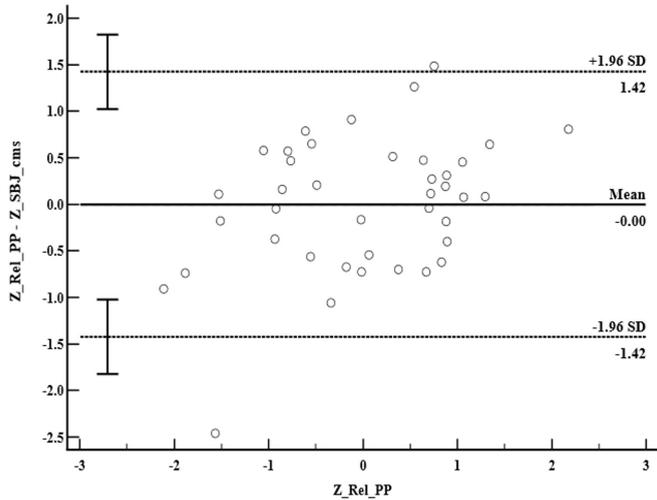| Variable | Male | | Female | | T-Value | P-Value |
|---|---|---|---|---|---|---|
| | Mean | Standard Deviation | Mean | Standard Deviation | | |
| Wingate Peak Power (watt) | 571.85 | 114.14 | 292.64 | 72.41 | 8.27 | 0.000 |
| Wingate Relative Peak Power | 8.32 | 1.56 | 5.82 | 1.27 | 5.13 | 0.000 |
| Vertical Jump Height (cm) | 40.46 | 6.08 | 29.93 | 5.51 | 5.39 | 0.000 |
| Standing Broad Jump Distance (cm) | 202.64 | 25.42 | 139.91 | 11.29 | 8.74 | 0.000 |



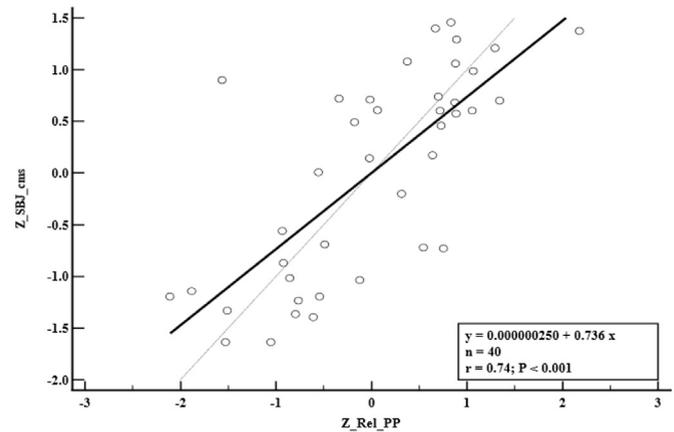**Figure 1.** Bland-Altman Plot comparing Standing Broad Jump and Wingate



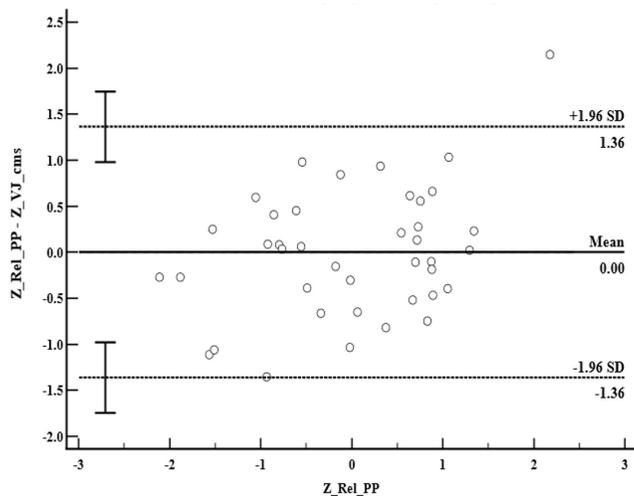**Figure 3.** Linear Regression comparing Z-score of Standing Broad Jump and Wingate.



**Figure 2.** Bland-Altman Plot comparing Vertical Jump and Wingate
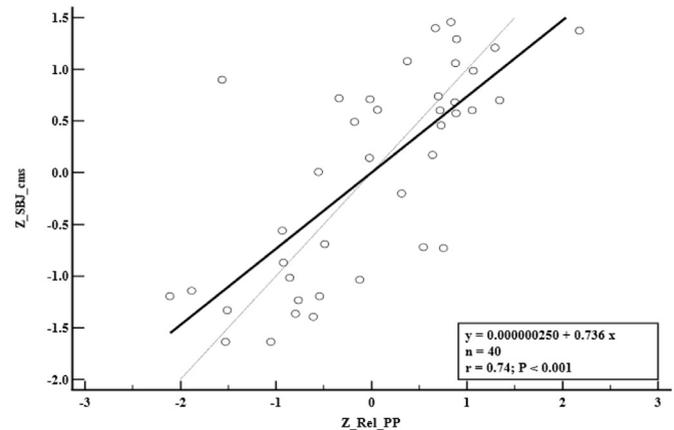


**Figure 4.** Linear Regression comparing Z-score of Vertical Jump and Wingate

## Discussion

This study shows a significant linear correlation between the SBJ, VJ, and Wingate cycle ergometer. Therefore, the VJ and SBJ can be appropriate field tests for measuring anaerobic fitness in athletes.

The positive relationship between Wingate's relative peak power and VJ height was (r = 0.76, p < 0.05). On Bland-Altman plots, about 97.5% of the relative peak power and VJ height were within acceptable limits of agreement. In earlier studies, similar relationships have been observed in untrained and trained athletes [10, 11, 12, 13, 14]. The results of this study showed similar results to previous studies performed on Indian athletes, which demonstrated a weak positive association between the peak and mean power of the VJ and the Wingate test (r = 0.220, p < 0.05); (r = 0.263, p < 0.05) in football [15]. In a study of female volley-

ball players, single jumping tests showed stronger correlations (r = 0.54, p = 0.001) with peak power in the Wingate test [16]. Similarly, a study found a significant VJ's validity as a field test for anaerobic power (r = 0.85) in basketball players [17].

The positive relationship between Wingate's relative peak power and SBJ distance was good (r = 0.74, p < 0.05). Bland-Altman plots showed that approximately 95% of relative peak power and SBJ distance were within the allowable agreement. A substantial correlation was found between Wingate and SBJ in earlier research [18, 19]. A study on 95 elite Indian sportsmen also discovered a positive relationship between SBJ and Wingate peak power in weightlifters (r = 0.446, p < 0.001) [20].

The current study focused on soccer players. Soccer is known for its combination of anaerobic and aerobic demands. The inclusion of soccer players is relevant, as their sport involves repeated sprints, jumps, and changes in direction, all of which rely on anaerobic power. Soccer players often exhibit well-developed lower body strength and power due to the nature of their training and gameplay, making the SBJ and VJ suitable tests for evaluating their anaerobic performance. Previous research on soccer players has demonstrated that these field tests can accurately reflect anaerobic fitness, and our study further supports the utility of these tests within this population [15].

Some limitations must be considered before the interpretation of the study results. For the study, the sample size was small. Future studies must be done with a larger sample size and athletes from various sports. We can also use a multiple regression model to assess the predictability of these tests for Wingate power. Therefore, when estimating lower limb peak power in trained elite athletes, the VJ and SBJ significantly agree with the Wingate test. They can be used instead of Wingate if no gold standard tests are available for anaerobic power.

### Conclusions

The findings indicate that both SBJ and VJ tests can be used as valid field measures of anaerobic power because the percentage of points lying in the agreements for the SBJ was 95 %, and for the VJ it was 97.5 %. Therefore, it can be used as an alternative method to assess lower-limb power, monitor the efficacy of training protocols, as a pre-indicator of injury, and as a pre-recruitment test in centers where Wingate testing ergometers are unavailable.

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