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RESEARCH ARTICLE

The Correlational Study of the Vertical Jump Test and Wingate Cycle Test as a Method to Assess Anaerobic Power in Road Cyclists

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Abstract
Road Cycling is an important sport that uses anaerobic and aerobic metabolism and especially sprinter cyclists have higher anaerobic capacity. The assessment of anaerobic power in cyclists often involves the use of the vertical jump and Wingate cycle tests. The lack of research in the field of cycling-specific tests to assess anaerobic performance has led to the improvement of existing research. The objective of this research was to investigate the correlation between the vertical jump test and the Wingate anaerobic cycling tests, both of which are often used to assess anaerobic power in road cyclists. A correlation study was conducted on 15 athletes of the Turkish national road cycling team in the 14-16 age group (15.107 ± 0.717 (SD)). The sample of the study was determined by using the convenient sampling method. On the first day, anthropometric measurements and the vertical jump test were conducted. The Wingate cycle ergometer test, lasting for a duration of 30 seconds, was administered to the participants on the second day. The computer application was used to determine the 30-second peak and average anaerobic power during the test. The results acquired from the study revealed a statistically significant positive relationship between the vertical jump performance and the peak power production measured during the Wingate cycle test (r=0.321, p<0.05). The findings indicate that vertical jump tests may serve as suitable field measurements of anaerobic power for road cyclists, as an alternative to the laboratory-based Wingate anaerobic test.

Keywords
Cycling, Vertical Jump, Wingate Anaerobic Test

INTRODUCTION

Anaerobic power, also known as anaerobic fitness, is a localized attribute of a muscle that is not reliant on the provision of blood and oxygen to that specific muscle" (Fleck and Kreamer, 1997). The capacity of an individual's muscular system to produce substantial levels of power is often regarded as a reliable indicator of athletic achievement (Bompa, 1993). Brooks et al. (2000) opt to utilize the term "high-intensity exercise" as an alternative descriptor for anaerobic power, deviating from the prevailing terminology. Anaerobic power tests are now used to evaluate an athlete's capacity to generate both power and speed in a brief amount of time or over a relatively short distance in both clinical and field settings (Stauffer, 2005).

In several sports, including particular athletics and cycling disciplines, gymnastics, combat sports, as well as various games and winter sports, the execution of explosive movements, such as jumping, accelerating, changing direction, or propelling an item or opponent, plays a substantial role in determining performance outcomes." The execution of such actions is predominantly contingent upon the capacity to produce muscular

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contractions and exert external force at considerable speeds, spanning a temporal range of milliseconds to seconds (Gross &Lüthy, 2020). The term used to describe this capacity is referred to as explosive power (Stone et al., 2007). “The capacity described can alternatively be denoted as muscular strength” (Markovic & Jaric, 2007) or anaerobic power, as the combination of force and velocity indicated in this context aligns with mechanical strength, and the energy needed for muscle exertion is not generated aerobically during these brief periods of activity (Heck et al., 2003).

Professional road cyclists often cover a distance ranging from 25,000 to 35,000 kilometers annually, including races and training at high altitudes. The most important characteristics of road cyclists are expressed in the literature with their high aerobic capacity, maximal power output (w) and maximal oxygen uptake (VO_2max) (Mujika&Padilla, 2001).

Athletes' anaerobic power is often assessed using the Wingate anaerobic test (WAnT) and vertical jump tests, which provide invaluable insights into the anaerobic performance of athletes in a variety of sports” (Changela& Bhatt, 2012). In numerous strength-oriented sports including football, basketball, tennis, and track and field, the Wingate Anaerobic Test has been used as a measure for evaluating anaerobic fitness levels and the efficacy of anaerobic training plans” (Choppin et al., 2012).

In many athletic disciplines, the vertical jump test is a standard method of assessing the lower extremities' explosive strength. In the context of football and volleyball players, the validity and reliability of such techniques are often investigated (Hespanhol et al., 2013). “The basic purpose of the vertical jump test is for the athlete to accomplish the greatest vertical displacement of the body's center of gravity, known as vertical height, during each subsequent leap within a certain time window.” The mechanical power created during the propulsion phase dominates the vertical displacement seen during a leap. The average power output, measured in Watts, is typically used to estimate the vertical jump test performance. The estimate may be easily determined using Harman's approach (Theodorou et al., 1998). When used to calculate peak power and average power during the vertical jump evaluation, the Harman et al. (1991) method has been found to be both reliable and valid.

There is a lack of comprehensive academic investigation that has been undertaken to examine the relationship between the vertical jump test and the Wingate anaerobic test as measures of anaerobic power in road cyclists. The main objective of this research study was to investigate a possible correlation between the vertical jump test and the Wingate anaerobic test, with the purpose of evaluating the extent of anaerobic power in cyclists.

MATERIALS AND METHODS

Participants

The present study uses a cross-sectional design, using the relational screening model to investigate the research question. The investigation involves the selection of a suitable sample participant group, which is then assessed under two distinct conditions. The study's sample was determined by the use of the easy sampling approach. According to Buyukozturk et al. (2018), the convenient sampling approach is characterized by the preference for readily and rapidly accessible units, mostly owing to practical constraints such as limited labor force and time availability. Consequently, the study intends to include a sample of 15 male road cyclists, aged 14-16, who are members of the national team of Turkey, on a voluntary basis. The present research has obtained approval from the Non-Invasive Clinical Research Ethics Committee of Fenerbahçe University, with the reference number 12.04.2023/76.2023fbu. All participants provided written informed consent.

Study Design and Data Collection

Anthropometric measurements and vertical jump test were done on the first day for the athletes whose sample was selected according to the convenient sampling method. On the second day, 30-second Wingate anaerobic cycling test was applied to the athletes and during the test, 30-second peak and average anaerobic power calculations were made with a computer program.

Research variables

Independent Variable: Explosive power (Wingate anaerobic cycling test)

Dependent Variable: Vertical Jump Test

Inclusion Criteria

1. Participate in competitions.
2. To be a 14-16 men's national team athlete.

Exclusion Criteria

Athletes who have had any joint injury and/or ligament injury in the last three years. In the study to be conducted, there are 2 tests besides taking the anthropometric measurements of the participants. The Vertical Jump Test will be applied as the 1st test and the Wingate Anaerobic Bicycle Test will be applied as the 2nd test. Personal (age, body weight, etc.) data obtained from laboratory tests were recorded in a single data collection form created by the researcher.

Working Process

After obtaining permission from Fenerbahçe University Non-Invasive Clinical Research Ethics Committee; The working process has started by obtaining the necessary permissions from the Turkish Cycling Federation and Fenerbahçe

University Sports Research Application and Research Center.

After the measurement methods to be applied were explained to the participants, the measurement devices were optimized and the measurement environment and the athletes were made ready. First of all, the participants; Anthropometric measurements (height and body weight) were taken. After a routine warm-up on the bike, the participants were given a vertical jump test. Participants were asked not to do high-intensity exercise, not to consume alcohol or heavy caffeine-containing foods and foods within 48 hours before coming to the test. It was paid attention that the athletes participating in the study had their last meal between 09:00 and 17:00 on weekdays and 3 hours before the measurements, and they were included in the study at the normal satiety level.

Height and Body Weight Measurement

The height and length measurements of the volunteer cyclists were measured with a stadiometer (Holtain Ltd, UK) fixed to the wall with an accuracy of ±0.1mm. Body weights were measured with an electronic laboratory scale (Seca, Vogel &Halke, Hamburg) with an accuracy of ±0.1 kg.

Cyclists did not wear thick clothes and socks so that the appropriate body position could be given during the measurements. Measurements were taken with the heads of the subjects in the "Frankfort Horizontal Plan" position, the arms on the side of the body and the palms facing the legs, of the subjects whose body weight was evenly distributed on both legs. When the heels touch each other, the angle on the inside of the feet is approximately 60°. All height measurements were taken with the heels, hips and scapula touching the platform in a vertical position and subjects in an upright position. Body weights were calculated by Lohman et al. (1988) suggested.

Vertical Jump Test

The participants of the research started the exercise session by adhering to a warm-up routine, which involved engaging in cycling for a period of 5-7 minutes on the 894 Ea, Peak Bike produced by Monark AB, a company based in Sweden. Furthermore, the participants performed a stretching protocol lasting 5-7 minutes, during which they maintained a cycling cadence of 55-60 revolutions per minute, without the inclusion of any external resistance. After the initial warm-up session, the participants proceeded to partake in a period of rest lasting for a length of 5 minutes. The studies involving vertical jumps were carried out using a customized power platform called the Sport Expert TM (MPS-501, Tümer Electronic LDT, Turkey). In all test circumstances, specifically the Squat Jump and Counter Movement Jump, each participant performed a total of three leaps. The maximum recorded value from the three trials was chosen for later analysis (Atabek, 2014).

Wingate Anaerobic Cycling Test

The Wingate Anaerobic Test (WAnT) was performed on a bicycle ergometer model 894 Ea, also known as the Peak Bike, manufactured by MonarkAB and equipped with mechanical brakes. Participants will be placed on the ergometer, and appropriate modifications will be made to ensure the best riding posture. Individual seat heights were changed to suit each participant's preferences, and striped nose clips were used to limit the probability of feet sliding off the pedals. The study was carried out in accordance with the standardized procedures given by Inbar et al. (1996). “The Wingate Anaerobic Test (WAnT) procedure consisted of administering a load for 30 seconds, with the resistance set at 7.5% of the individual's body mass. Before the resistance was added, the participants were instructed to cycle with their greatest effort.” The WAnT software, developed by Inhabar et al. (1996), was used to automate the calculation and recording of various power measures. Absolute peak power output (APP), relative peak power output (RPP), absolute average power output (AMP), relative average power output (RMP), and lowest power output were among the criteria considered. The calculations were carried out using a computer equipped with the Swedish Monark Exercise AB system.

Laboratory tests carried out within the scope of the study were carried out in Fenerbahçe University, Sports Research Application and Research Center in May 2023.

Statistical analysis

The information was evaluated statistically with the help of the SPSS 24.0 program. Using Descriptive statistics, we were able to provide a comprehensive evaluation of the sample as a whole. The average and standard deviation of the test results were calculated. The normality of the data was assessed using the Kolmogorov-Smirnov test, while the homogeneity of variance was assessed using the Levene test. The present research used Pearson correlation analysis to examine the relationship between the Wingate Anaerobic Cycling Test and vertical jump performance. The utilization of one-way regression analysis was used to ascertain the influence of the independent variable on the dependent variable in the presence of a correlation between the two variables. The threshold for statistical significance was established at a significance level of $p < 0.05$.

RESULTS

Table 1 shows the demographic characteristics of the participants. The ages, weights, heights, BMIs, and body fat percentages of the cyclists were computed.

Table 1. Demographic characteristics of the participants

Variable	Mean	Std.	Min.	Max.
Age (years)	15.107	0.717	14.000	16.000
Body Weight (kg)	63.500	7.361	49.200	80.500
Body Height (cm)	173.467	7.090	157.000	183.000
BMI (kg/m²)	20.960	2.611	17.000	26.900
Body Fat (%)	11.640	5.629	4.300	24.600

n=15; BMİ: Body Massİndex; Cm: centimetre; Kg: kilogram; Min: minimum; Max: maximum; Std: standart deviation

Table 2. Jump and wingate test data of the participants

Variable	Mean	Std.	Minimum	Maximum
CMJ	33.922	2.974	28.610	38.320
SJ	32.325	2.504	26.860	36.690
PeakWatt	1.047.613	150.780	816.880	1.316.070
PeakWatt/Kg	16.622	1.952	13.680	21.110
Avg. Watt	637.512	62.010	501.580	747.540
Avg. Watt /Kg	10.113	0.510	9.340	11.200

n=15; CMJ: CountermovementJump; SJ: SquatJump; Std: standart deviation

The results of the participants jump and wingate tests are shown in Table 2. Table 3 analysis revealed that CMJ and SJ had a statistically significant relationship (p0.001),between Peak Watt/Kg andboth CMJ and SJ (p0.05), and between Avg. Watt/Kg and both PeakWatt/Kg and SJ. Examining Table 4, it was determined that the Peak Watt/Kg value accountedfor 32% of the variance in CMJ, which was statistically significant.

Table 3. Pearson'scorrelationanalysisdata of theparticipants

Variable		CMJ	SJ	PeakWatt/Kg	Avg. Watt /Kg	BMİ
CMJ	Pearson's r	—				
SJ	Pearson's r	0.814***	—			
PeakWatt/Kg	Pearson's r	0.559*	0.550*	—		
Avg. Watt /Kg	Pearson's r	0.475	0.316	0.653**	—	
BMİ	Pearson's r	0.074	0.031	−0.122	−0.321	—

* p < 0,05, ** p < 0,01, *** p < 0,001; BMİ: Body Massİndex; CMJ: CountermovementJump; SJ: SquatJump; Kg: kilogram

Table 4. Regression analysis data of the participants

	Std. Error	Coefficients Beta	t	p	R Square
PeakW/Kg	0,004	0,57	2,501*	,027*	0,321

DependentVariable: CMJ; *P<0,05 **p<0,01 ***p<0,001

DISCUSSION

The findings of this study indicated a statistically significant positive correlation (p<0.001) between the countermovement jump (CMJ) and the squat jump (SJ). Moreover, the production of peak power per kilogram (Peak Watt/Kg) was shown to be significantly correlated with both the countermovement jump (CMJ) and the squat jump (SJ) (p<0.05). Ultimately, a significant statistical correlation was identified between the mean power output per kilogram (Avg. Watt/Kg) and the maximum power output per kilogram (Peak Watt/Kg).

The Vertical Jump and Wingate anaerobic power tests demonstrate a strong dependence on the ATP/PC energy system, which is responsible for generating and maintaining peak anaerobic power. Moreover, it is worth noting that the performance of the participants in each of the aforementioned tasks was significantly influenced by the independent variable of weight. The research revealed that participants with greater muscle mass had higher levels of anaerobic power outputs in both the Vertical Jump and Wingate tests. “Prior research has used the vertical jump and Wingate power tests to evaluate the anaerobic contributions of persons engaged in sporting activities and leisure physical activity. The tests being discussed have been shown to possess a good level of validity and reliability, as supported by existing academic research” (Stauffer, 2005).

The significance of anaerobic performance has considerable relevance across several athletic disciplines. The recognition of the need for expeditious and substantial power production in many sports scenarios, including defensive maneuvers in team-based competitions, sprinting, throwing and leaping disciplines, and a multitude of other athletic endeavors, is widely accepted. “The concept of anaerobic performance encompasses two essential components, namely anaerobic power and anaerobic capacity. The term "anaerobic power" pertains to the ability to use the phosphagenic system, while "anaerobic capacity" is linked to the capability to extract energy from a combination of anaerobic glycolysis and the phosphagen system.” The performance of anaerobic exercises may be influenced by a range of parameters, “including body composition, sex, age, muscle fiber composition, muscle cross-sectional area, strength, and training “(Kin-Isler et al., 2008). The relationship between the dynamic and static contraction power of the lower extremities and anaerobic power performance is significant, especially in sports disciplines that require quick and powerful movements. The factors listed above have considerable importance in evaluating sports performance (Fox et al., 1993). The Wingate anaerobic power test is a popular and reliable method for measuring the most power that can be generated by the lower leg muscles in an anaerobic state (Inbar et al., 1996).

The measurement of mechanical power has great significance in the assessment of performance across several disciplines, including both sports and routine activities. As a result, a significant amount of research has been devoted to this field over a substantial period of time. The examination of athletes' vertical leaping ability often involves the use of the Squat Jump (SJ) and Countermovement Jump (CMJ) tests. Newton et al. (2006) “state that the evaluation of lower-body concentric strength/power is often referred to as SJ, whereas CMJ is used as a measure for assessing lower-body reactive strength/power.” The aforementioned trials provide empirical support for the efficacy and pertinence of the SJ and CMJ tests as valid measures for assessing the force and power capabilities of athletes' lower extremities (Riggs & Sheppard, 2009). During the execution of various kinds of leaps, the central nervous system employs distinct motor programs to facilitate the synchronization of neuromuscular activity required for the completion of each individual jump. The squat jump (SJ) is generally acknowledged as a fundamental approach for evaluating explosive muscular power due to its exclusive reliance on concentric activation. The countermovement leap (CMJ) necessitates a modest level of eccentric activation, followed by a subsequent substantial level of concentric activation. Consequently, it necessitates a more intricate coordination and recruitment of motor units. Therefore, the squat jump (SJ) may be used as a standard for evaluating explosive muscular strength, whereas the countermovement leap (CMJ) can provide significant insights into the enhancement of this capability (Bencke et al., 2002).

The results of the present study indicate a statistically significant association between Peak Watt/Kg and many indicators of jump performance, such as height, total effort, and anaerobic power. In a study conducted by Stauffer et al. (2010), “a robust and statistically significant correlation (r=0.85) was identified between peak power, as measured through vertical jump assessments, and the Wingate Anaerobic Test (WAnT) in a cohort of 13 female basketball players (mean age: 19.7±1.1 years).”Farlinger et al. (2007) performed a study with the objective of investigating the association between vertical jump height and modified Wingate performance measures. These measures included average power output (APP), average mean power (AMP), relative power output (RPP), and relative mean power (RMP). The research investigation centered on a cohort of adolescent and young adult male athletes engaged in competitive ice hockey, ranging in age from 15 to 22 years. The mean age of the participants was calculated to be 16.3±1.7 years. The analysis yielded results indicating a range of correlation coefficients (r values) spanning from 0.63 to 0.69. Furthermore, previous research has shown a significant correlation of 0.88 and 0.89 between the peak power measured by vertical jump and the absolute Wingate performance (APP, AMP) respectively. On the other hand, the research carried out by Farlinger et al. (2007) “demonstrated a correlation value of 0.46 between the peak power assessed by vertical jump and the relative performance in the Wingate test.” Additionally, a correlation coefficient of 0.33 was seen in connection to relative mean power. Arslan (2005) performed a research that demonstrated a significant positive relationship between APP, RPP, AMP, RMP, and vertical jump ability (r=0.60, r=0.49, r=0.63, r=0.59, respectively) among participants in a regular exercise group, including both males and females. Furthermore, Arslan (2005) “performed a research that revealed a noteworthy correlation between APP, AMP, and vertical jump performance (r=0.68, r=0.65, respectively) within the sedentary group.” Furthermore, previous research has shown a noteworthy correlation (r=0.56) between the Wingate Anaerobic Test-All-out Peak Power (WAnT-APP) and “vertical jump height in a sample of soccer players with a mean age of 19.6±0.8 years” (Miller et al., 2011).

In a research done by Bencke et al. (2002), it was noted that there existed a moderate link between the advancement of peak power (PP) and the performance of squat jump (SJ) and countermovement jump (CMJ) exercises, with correlation values of 0.41 and 0.46, respectively. The current study focused on a cohort of youngsters, including individuals of both genders, aged between 10 and 13 years. The youngsters exhibited enthusiastic participation in a variety of physical activities, including swimming, tennis, gymnastics, and handball. Based on the aforementioned findings, it has been shown that a modest correlation exists (r=0.36) between vertical jump performance and power production among a cohort of male athletes participating in national and international volleyball, basketball, and wrestling competitions. According to Saç and Taşmektepligil (2011), previous research has shown a moderate association between AMP, RMP, and vertical jump. This is supported by correlation coefficients of 0.35 and 0.43

respectively, as reported by Almuzaini and Fleck (2008).

By contrast, Almuzaini and Fleck (2008) looked at a group of 21.66±1.66 -year-olds who participated in a physical education program and found no significant relationship between APP, RPP, and vertical jump performance. Moreover, the research done by Emeterio and González-Badillo (2010) "demonstrated that there was no statistically significant correlation seen between the vertical displacement of countermovement jumps (CMJh) and the production of anaerobic power (APP) among a cohort of teenage skiers." The research included of male participants with a mean age of 14.6 ± 1.1 years, alongside female participants with a mean age of 14.9 ± 1.0 years. Furthermore, the study conducted by Eyuboğlu et al. (2009) "demonstrated that there was no statistically significant correlation observed between resting pulmonary pressure (RPP), resting metabolic rate (RMP), and countermovement jump height (CMJh) in a cohort of American football athletes with an average age of 23.07±3.45 years."Similarly, no significant association was seen between RPP and SJh. A significant positive connection was identified between SJh and RMP, yielding a correlation coefficient of 0.536. In addition, Alemdaroğlu (2012) has provided empirical evidence that establishes a significant correlation between the height of countermovement jumps (CMJh), the height of squat jumps (SJh), and the maximum power output (PP). Nevertheless, the statistical analysis revealed no statistically significant correlation between countermovement jump height (CMJh) and muscular power (MP).

Conclusion

The vertical jump, specifically the SJ and CMJ, is commonly employed as a measure of lower body power across various sports disciplines. Research findings have demonstrated that the vertical jump has the potential to serve as a reliable predictor of maximal anaerobic power. Consequently, coaches may find it advantageous to utilize the vertical jump as a convenient and straightforward field screening test (Kasabalis et al., 2005). The findings of the current investigation suggest that both squat jump (SJ) and countermovement jump (CMJ) have the potential to serve as reliable measures for assessing lower body power in road cyclists.

Conflic of interest

No conflict of interest is declared by the authors. In addition, no financial support was received.

Ethics Committee

This study is approved by Fenerbahçe University (FBU) Non-Invasive Clinical Research Ethics Committee (Approval Number: 12.04.2023/76.2023fbu)

Author Contributions

Planned by the author: Study Design, Data Collection, Statistical Analysis, Data Interpretation, Manuscript Preparation, Literature Search. Author have read and agreed to the published version of the manuscript.

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