**Manuscript Title:** Validity and test –retest reliability of the TIVRE-Basket® test for the determination of aerobic power in elite male basketball players

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**Authors and Affiliations:** A. Vaquera1,2, J.G. Villa1, J.C. Morante1, G. Thomas2, A. Renfree2, & D.M. Peters2,3

1 Faculty of Physical Activity Science and Sport, University of León, Leon 24071, Spain.

2 Institute of Sport & Exercise Science, University of Worcester, Henwick Grove, Worcester, United Kingdom, WR2 6AJ.

3 Faculty of Health & Sport Sciences, University of Agder, Kristiansand, Norway.

**Corresponding Author:** Andrew Renfree, Institute of Sport & Exercise Science, University of Worcester, Henwick Grove, Worcester, United Kingdom, WR2 6AJ.

Tel: +44 (0)1905 855376

Fax: +44 (0)1905 855132

Email: a.renfree@worc.ac.uk

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**ABSTRACT**

The aims of this study were to 1) determine the relationship between performance on the court-based TIVRE-Basket® test and peak aerobic power determined from a criterion lab-based incremental treadmill test and 2) to examine the test-retest reliability of the TIVRE-Basket® test in elite male basketball players. To address aim 1, 36 elite male basketball players (age 25.2 + 4.7 years, weight 94.1 + 11.4 kg, height 195.83 + 9.6 cm) completed a graded treadmill exercise test and the TIVRE-Basket® within 72 hours. Mean distance recorded during the TIVRE-Basket® test was 4001.8 + 176.4m, and mean VO2 peak was 54.7 + 2.8 ml.kg.min-1, and the correlation between the two parameters was *r=*0.824 (*P*= <0.001). Linear regression analysis identified TIVRE-Basket® distance (m) as the only unique predictor of VO2 peak in a single variable plus constant model: VO2 peak = 2.595 + ((0.13\* TIVRE-Basket® distance (m)). Performance on the TIVRE-Basket® test accounted for 67.8% of the variance in VO2 peak (t=8.466, P=<.001, 95% CI 0.01 - 0.016, SEE 1.61). To address aim 2, 20 male basketball players (age 26.7±4.2; height 1.94±0.92; weight 94.0±9.1) performed the TIVRE-Basket® test on two occasions. There was no significant difference in total distance covered between Trial 1 (4138.8 + 677.3m) and Trial 2 (4188.0 + 648.8m; t = 0.5798, P = 0.5688). Mean difference between trials was 49.2 + 399.5m, with an ICC of 0.85 suggesting a moderate level of reliability. Standardised TEM was 0.88%, representing a moderate degree of trial to trial error, and the CV was 6.3%. The TIVRE-Basket® test therefore represents a valid and moderately reliable court-based sport-specific test of aerobic power for use with individuals and teams of elite level male basketball players. Future research is required to ascertain its validity and reliability in other basketball populations e.g. across age groups, at different levels of competition, in females and in different forms of the game e.g. wheelchair basketball.

**KEY WORDS** field testing, team sports, sport-specific, peak V02, fitness

**INTRODUCTION**

It is widely recognised that field based tests for sport relevant physical fitness need to be sport specific, engaging for participants, capable of use with multiple players simultaneously and practical yet incorporate acceptable levels of both validity and reliability.

The TIVRE-Basket® test has been proposed as a sport-specific, court-based, multiple player method of assessing maximal aerobic power in high level basketball players (7,8). Although the nature of typical match play would suggest the aerobic energy system is highly active throughout games, previously reported aerobic power values for basketball players have typically been estimated from non-basketball-specific tests (6). As such sport specific aerobic power in basketball players has yet to be determined and clearly this supports the need for the development and testing of a test such as the TIVRE-Basket®. Until sport-specific aerobic power can be more accurately determined, analysis of the relationship between basketball specific V02 and other clearly basketball-specific parameters such as vertical jump ability, cannot be explored with any degree of certainty. The TIVRE-Basket® test is currently being used by a number of coaches and teams in Europe, its procedures are publicly available and its use is widely evident in online forums e.g. <http://g-se.com/es/org/stefano-benitez/biblioteca/presentacion-del-test-tivre-basket>; <http://www.acb.com/redaccion.php?id=69806>.

Despite such widespread popularity, there is no published research available to confirm its criterion validity or test-retest reliability. The aims of this technical report therefore were 1) to determine the ability of the distance covered on the TIVRE-Basket® test to predict directly measured peak aerobic power (criterion validity), and 2) to examine the test-retest reliability of both predicted peak aerobic power and distance covered during the TIVRE-Basket® test in elite male basketball players.

**TIVRE BASKET TEST**

The TIVRE-Basket® test is conducted on a full sized basketball court. Participants are required to run around the cones set out at 8 metre intervals on a basketball court (figure 1) at a speed determined by an audio pacer programme run through a laptop computer. Participants are instructed to arrive at each cone in time with audible ‘beep’. If a participant is judged by an observer to have failed to reach the cone on or before the ‘beep’ on three consecutive occasions, they are withdrawn from the test. The test commences at an initial running speed of 7.8 km.h-1 with speed increased by 0.6 km.h-1 between consecutive stages. A stage consists of three laps of the 96 metre circuit followed by 30 seconds of active recovery. The next stage is then initiated by a ‘beep’ and the participants are required to complete the next circuits in the opposite direction. Total distance completed (in 8 metre increments) is recorded for each participant at the end of the test.

Please insert Figure 1 here

**Ethical approval**

All procedures were conducted in accordance with approval of the Human Ethics Committee of Leon University, and in accordance with the Helsinki Declaration. All participants completed a pre-participation general health screening questionnaire and were not taking medications that influenced heart rate. Each participant was informed about the research design and the requirements, benefits and risks of the study and each provided written informed consent prior to their participation.

**Aim 1: Relationship between TIVRE-Basket**® **and peak VO2**

Thirty six male professional basketball players ((mean+SD) age 25.2 + 4.7 years, weight 94.1 + 11.4 kg, height 195.83 + 9.6 cm)) from the Spanish ACB League completed a graded treadmill exercise test and the TIVRE-Basket® test within a maximum of 72 hours.

Testing for both studies presented in this report was conducted during the competitive period when participants trained for 10-14 hours (8-10 hours of technical-tactical sessions, plus 2-4 hours of physical training sessions) and played one or two competitive matches per week. Training load was reduced on the day preceding each test which was performed between 12.00 and 2.00pm. Participants were advised to follow their normal pre-training dietary and hydration practices.

The graded exercise test was performed on a motorised treadmill (PowerJog M30), set at a 1 % gradient (5). Participants commenced running at an initial speed of 6 km.h-1, which was increased incrementally by 0.5km.h-1 every 30s until volitional exhaustion. During the test, breath-by breath respiratory gas exchange parameters were analysed using the Oxycon Alpha system (Jaeger, Germany), and measurement of expired gas volumes was performed using a Hans Rudolph pneumotachograph. (Model 3800, Kansas. USA). VO2 peak was taken as being the highest recorded VO2 in the final two minutes of exercise (4).

The relationship between TIVRE-Basket® distance covered (m) and VO2 peak was investigated using Pearson correlation and a linear regression equation was then produced using the entry method with TIVRE-Basket® distance covered (m), age, height, weight, and a constant used to predict VO2 peak.

**RESULTS**

Mean distance recorded during the TIVRE-Basket® test was 4001.8 + 176.4m, and mean VO2 peak was 54.7 + 2.8 ml.kg.min-1. The correlation between the two parameters was *r=*0.824 (*P*= <0.001) and due to their relatively normal distribution linear regression analysis was deemed appropriate. Entry method linear regression analysis identified TIVRE-Basket® distance (m) as the only unique predictor of VO2 peak in a single variable plus constant model generating the following prediction equation: VO2 peak = 2.595 + ((0.13\* TIVRE-Basket® distance (m)).

Performance on the TIVRE-Basket® test accounted for 67.8% of the variance in VO2 peak (t=8.466, P=<.001, 95% CI 0.01 - 0.016, SEE 1.61).

**Aim 2: Test-retest reliability**

Reliability of the TIVRE-Basket® test was determined through assessment of the agreement between the distance covered and the VO2 peak from the previously developed prediction equation results generated in consecutive performances of the test. After an initial familiarisation trial, 20 male basketball players who competed in the Spanish LEB division and who had not been included in the development of the prediction equation performed the test on two occasions separated by no more than 18 days ((mean±SD) age 26.7±4.2; height 1.94±0.92; weight 94.0±9.1).

Differences in performance and predicted variables generated between repeated performances of the test were assessed using a t-test for repeated measures using Graphpad Prism 6 software. Reliability of variables was determined by using the Spreadsheet for Calculating Reliability (3). Trial to trial reproducibility was determined through calculation of the mean difference with 90% confidence limits. Also calculated was the intra-class correlation coefficients (ICC), and an ICC of greater than 0.90 was considered to be high, of between 0.80 and 0.89 was considered moderate, and below 0.80 was considered questionable (9). The degree of measurement error was expressed as the standardised typical error of the estimate. Log transformed data was also used to generate a CV for each parameter. Individual data points and mean bias between trials are presented via Bland-Altman plots

There was no significant difference in the total distance covered in the two consecutive trials (Trial 1; 4138.8 + 677.3m, Trial 2; 4188.0 + 648.8m) (t = 0.5798, P = 0.5688). The mean difference between the trials was 49.2 + 399.5m (figure 2), and an ICC of 0.85 suggested a moderate level of reliability. Standardised typical error of measurement was 0.88%, also representing a moderate degree of trial to trial error, whilst the CV was 6.3%.

 Please insert Figure 2 here

There was no significant difference in predicted VO2 peak between the two tests (Test 1; 56.4+ 8.8 ml.kg.min-1, Test 2; 57.0 + 8.4 ml.kg.min-1) (t = 0.5704, P = 0.5751). Mean difference between trials was 0.60 + 4.90 ml.kg.min-1 (figure 3), and an ICC of 0.85 for predicted VO2 peak also suggests a moderate level of reliability. Standardised typical error of measurement was 0.88%, again representing a moderate degree of trial to trial error, whilst the CV was 6.9%.

Please insert Figure 3 here

**DISCUSSION**

The validity and test-retest reliability statistics determined for the TIVRE-Basket® test in this study were found to be better than statistical findings presented for more commonly used field tests of aerobic power in basketball athletes e.g. the Yo-Yo intermittent recovery test correlating with treadmill determined VO2 peak r=0.77 with 59% shared variance (1) and another recently proposed test in soccer players e.g. peak velocity in the Carminatti’s test was only moderately correlated (r=0.52) with treadmill determined VO2 max (2).

It is therefore concluded that the TIVRE-Basket® test represents a better more valid and reliable sport-specific, court based individual and multi-player test of aerobic power for use with elite level male basketball players than is currently available. Future research is required to investigate if the TIVRE-Basket® is valid and reliable in assessing aerobic power in other basketball populations such as females, across different age groups, at different levels of competition and in different forms of the game e.g. wheelchair basketball.

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**FIGURE LEGENDS**

Figure 1. Structure of the TIVRE-Basket® test

Figure 2. Bland-Altman plot of the differences in total distance covered (m) between Test 1 and Test 2.

Figure 3. Bland-Altman plot of the differences in predicted VO2 peak (ml.kg.min-1) between Test 1 and Test 2.