European Journal of Human Movement, 2018: **40**, 136-148

FIELD TEST VALIDATION FOR WHEELCHAIR BASKETBALL PLAYERS' AEROBIC CAPACITY ASSESSMENT

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ABSTRACT

The aim of this study was to prove the validity of a shuttle run, multistage type maximum continuous incremental field test in wheelchair basketball players (WBP) for estimating individual peak oxygen uptake (VO_{2peak}) from the distance covered on the basketball court. Seven male elite players performed a laboratory maximum incremental ergospirometric laboratory test on a wheelchair treadmill until volitional exhaustion. For field test, mean data were: distance covered 1562.7 m (s = 323.0), maximal heart rate (HR_{max}) 179.2 beats·min_{-1} (s = 11.7), total time test 11 min 01 s (*s* = 1 min 47s) and maximum velocity 11 km·h^{-1} (*s* = 0.8). For the laboratory test, mean data were: absolute VO_{2peak} 2.9 l·min^{-1} (*s* = 0.4), relative VO_{2peak} 40.6 ml·kg^{-1}·min^{-1} (*s* = 7.2), HR_{max} 182.2 beats·min^{-1} (*s* = 12), total time test 10 min 4 s (*s* = 1 min 57 s) and maximum velocity 10.8 km·h^{-1} (*s* = 1.0). Pearson product rank correlations between variables for both tests were high, with special consideration for the relationship between VO_{2peak} measured in the laboratory (40.59 ml·kg^{-1}·min^{-1}; *s* = 6.92) and the distance covered in the field test (1562.67 m, *s* = 323.96; r = 0.854; p<0.01). The results suggest that the test designed is a valid predictor of VO_{2peak} as an indicator of aerobic performance in elite WBP.

Key words: wheelchair basketball, aerobic assessment, paralympic sport, sport performance, fitness

VALIDACIÓN DE UN TEST DE CAMPO PARA LA EVALUACIÓN DE LA CAPACIDAD AERÓBICA, EN JUGADORES DE BALONCESTO EN SILLA DE RUEDAS

RESUMEN

El objetivo de este trabajo fue el validar un test de campo incremental, continuo, máximo, multinivel de ida y vuelta en jugadores de baloncesto en silla de ruedas (BSR) para la estimación de su consumo pico de oxígeno (VO_{2pico}) a partir de la distancia recorrida en la pista de baloncesto. Siete jugadores de élite fueron evaluados usando un test ergoespirométrico máximo incremental sobre un tapiz rodante en laboratorio hasta el agotamiento. Para el test de campo, los datos medios fueron distancia recorrida 1562.7 m (s = 323.0), frecuencia cardíaca máxima (FC_{max}) 179.2 pulsaciones·min_{-1} (s = 11.7), tiempo total 11 min 01 s (*s* = 1 min 47s) y velocidad máxima 11 km·h^{-1} (*s* = 0.8). Para el test de laboratorio los datos medios fueron VO_{2pico} absoluto 2.9 l·min^{-1} (*s* = 0.4), VO_{2pico} relativo 40.6 ml·kg^{-1}·min^{-1} (*s* = 7.2), FC_{max} 182.2 pulsaciones·min^{-1} (*s* = 12), tiempo total del test 10 min 4 s (*s* = 1 min 57 s) y velocidad máxima 10.8 km·h^{-1} (*s* = 1.0). La correlación de Pearson entre las variables de ambos test fueron altas, con especial consideración en la relación entre VO_{2pico} medido en laboratorio (40.59 ml·kg^{-1}·min^{-1}; *s* = 6.92) y la distancia recorrida en el test de campo (1562.67 m, *s* = 323.96; r = 0.854; p<0.01). Los resultados sugieren que el test diseñado es un predictor válido del VO_{2pico} como un indicador del rendimiento aeróbico en jugadores de BSR de élite.

Palabras clave: baloncesto en silla de ruedas, evaluación aeróbica, deporte paralímpico, rendimiento deportivo, condición física

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Submitted: 06/01/2018 *Accepted:* 12/06/2018

INTRODUCTION

Wheelchair basketball is, probably, the most practiced adapted and Paralympic sport worldwide, and its players became in the last years professionals in the top club competitions. Competition and training tools for fitness screening and assessment become crucial for adequate elite preparation. In this regard, several studies have studied the cardio-respiratory response and aerobic power of elite wheelchair basketball players (WBP) in laboratory tests using a wheelchair (Coutts, 1990, 1995; Goosey-Tolfrey & Tolfrey, 2008; Goosey-Tolfrey, 2005; Knechtle & Köpfli, 2001; Rostein et al., 1994; Schimd et al., 1998; van der Woude, Bouten, Veeger & Gwinn, 2002; Veeger, Hadj Yahmed, van der Woude & Charpentier, 1991). These studies reveal, among other aspects, that there is a lineal relationship between the VO_{2peak} of WBP and their level of motor impairment and thus their functional classification. Although the ergospirometric laboratory tests provide important information on aerobic fitness, the technical difficulties involved in their administration make it necessary to implement specific tests for this type of population in the same facility where they carry out their sports activity (Goosey-Tolfrey & Leich, 2013). Also, very recently, in this population it has been demonstrated that both main ways to assess aerobic capacity, arm crank ergometer (ACE) and wheelchair ergometer (WCE) or wheelchair treadmill (WCT) may be useful when determining aerobic capacity in WBP (Molik et al., 2017).

However, not all WBP have regular access to laboratories where to test their aerobic capacity through these tests. That is way it is needed to develop tools for on court administrations to asses aerobic capacity. In our knowledge, very few studies have been carried out outside the laboratory on the physical fitness of people with a physical disability (Franklin et al., 1990; Rhodes, McKenzie, Coutts & Rogers, 1981; Vinet et al., 1996; Vanderthommen et al., 2002; Vanlandewijck, van de Vliet, Verellen & Theisen, 2006) or which have specifically included WBP in the sample (Vanlandewijck, Daly & Theisen, 1999; Vanlandewijck, Spaepen, Theisen, van de Vliet & Pétre, 1999; Goosey-Tolfrey & Tolfrey, 2008; Goosey-Tolfrey & Leich, 2013). Also, only one of the above mentioned studies analysed top level WBP. To date the results obtained have not made it possible to have a valid field test for analyzing aerobic capacity in these athletes in their respective sports context. The three studies mentioned used a maximum shuttle run type continuous incremental field test performed on the basketball court. This type of field test makes it possible to carry out the assessment in the sport facility in such a way that several players can be tested at the same time, thus favouring their motivation. In fact the classic version of the test (Léger & Lambert, 1982; Léger, Mercier, Gadoury & Lambert, 1988) is often used to assess the aerobic capacity of non-wheelchair basketball teams and even referees. The validation of a field test which made it possible to estimate VO_{2peak} would mean a step forward in the assessment of the WBP's physical fitness and an improvement in the evaluation methods available to teams and coaches as it would facilitate adapting the workloads and monitoring the training programme. For all of the above mentioned, the objective of this study was to prove the validity of a shuttle run type field test in WBP for estimating individual VO_{2peak} from the distance covered on the court.

METHOD

Participants

Seven players from an elite Spanish WB team (See Table 1) volunteered to participate in the study. All the players except one had belonged to their national teams. The training regime of the sample was 8 hours a week on the court, divided into 4 weekly sessions of 2 hours plus one league game per week. Some players supplemented this training regime with other strength and/or cardiovascular endurance training. All of the participants players were representing their country at the national male WB squad before the study. The players are assigned to a class according to the present classification of the International Wheelchair Basketball Federation (IWBF, 2014). The present study was approved by the institution´s ethical committee and written informed consent was obtained from all participants. The study was conducted according to the Declaration of Helsinki on research with human beings.

TABLE 1
General characteristics of the total sample (n = 7) at moment 1*.

Player	Age* (years)	Weight* (kg)	Height* (cm)	IWBF class	Disabilty	lesion level	Time since injury (years)	WB experience (years)
1	35	85.5	191	1	Paraplegia	D5 complete	14.0	14.0
2	29	62.8	178	1	Paraplegia	D5 complete	8.0	9.0
3	28	66.5	175	2	Paraplegia	D5-L2 incomplete	15.0	12.0
4	37	48.3	166	3	Poliomyelitis	2 legs	34.0	18.0
5	33	90.9	190	4	Poliomyelitis	Left leg	31.0	19.0
6	44	83.7	182	4	Poliomyelitis	Right leg	42.0	28.0
7	27	74.2	184	4.5	Amputation	Right leg (1/3 proximal)	19.0	4.0
X	33.3	73.1	181	2.8			23.3	14.9
DE	6.0	15.0	8.8	1.5			12.5	7.8

Procedure

The players carried out a field test and a laboratory test, described in detail below, with no more than a week between both of them. At the beginning of the study the players were already familiar with the administration procedure and protocol of each of the tests which were carried out at three different time points during the competitive season: at the end of November (time point 1), February (time point 2) and April (time point 3).

Field test

A maximum shuttle run type continuous incremental field test was designed to assess aerobic power using an adaptation of the test designed by Vanlandewijck et al. (1999a). The definitive protocol was determined after a pilot study with players from different functional classifications. The player had to perform the maximum number of periods (1 period = 1 minute) along a corridor of 28 x 3 m marked out with cones. The starting velocity for the first period was set at 6 $km \cdot h^{-1}$ and increased by 0.5 $km \cdot h^{-1}$ each minute, thus developing an incremental aerobic test with a sufficient duration of between 8 and 14 minutes to evoke a maximum cardio-respiratory response, which would be indicative of maximum aerobic capacity (Wasserman, 1987; Goosey-Tolfrey & Tolfrey, 2008). The velocity required for each period was used to establish the distance to be covered in the minute. The participants were given auditory feedback with a digital recording which emitted two types of acoustic signals: those that indicated the moment at which they had to reach the base line and those which signalled the beginning of a new period. The temporal reliability of the sound reproduction was checked. The test ended when the player was unable to reach the line twice in succession at the signal and the lineal distance covered was recorded subtracting the length of the final shuttle runs in which the line was not reached. The distance covered was checked again using the video recorded during the test. The players performed the test in two groups, of 3 and 4 participants, depending on their functional category, to favour their motivation in this maximum test. Each player wore a Polar Accurex Plus® heart rate monitor during the test for the telemetric measuring of his heart rate which was recorded at 5 second intervals. The data were collected and processed with Polar Interface Plus®, as well as the Polar Training Advisor® (Polar Electro, Kempele, Finland) software programme. The following variables were recorded: maximum heart rate ($beats \cdot min^{-1}$), distance covered (m), time taken (min;s) and maximum velocity reached ($km \cdot h^{-1}$). Estimated VO_{2peak} was calculated as a function of the distance covered on the court using the equation developed by Léger et al. (1988) for populations of over 35 without physical disabilities ($VO_{2peak\text{-}field}$).

Laboratory test

A maximum incremental ergospirometric test with a gradual increase in velocity and slope, designed specifically for this population by Rabadán et al. (2001), was carried out on a treadmill for wheelchairs. Each participant used his own wheelchair, except the players with an IWBF classification of 4 – 4.5 who used a chair of similar characteristics adapted to the width of the treadmill. The laboratory test was part of a comprehensive sports medical examination of the players. The test protocol was as follows: a) a 1 minute (min) warm up at 3 $km \cdot h^{-1}$ with 0% slope; b) the start of the test at 6 $km \cdot h^{-1}$ and 0% slope with constant increases in velocity of 0.125 $km \cdot h^{-1}$ and 0.04% slope every 15 seconds; c) a recovery period of 3 min 3 $km \cdot h^{-1}$ with 0% slope. The following variables were recorded: maximum ventilation (VE_{max}, $l \cdot min^{-1}$), absolute (VO_{2peak}, $l \cdot min^{-1}$) and relative ($VO_{2peak\text{-}lab}$, $ml \cdot kg^{-1} \cdot min^{-1}$) oxygen uptake, ventilatory equivalent for VO_2 and CO_2, respiratory exchange ratio (RER), maximum heart rate (HR_{max}, beats$\cdot min^{-1}$), time taken (min;s), maximum velocity (Vel_{max}, $km \cdot h^{-1}$) and maximum slope (Slope, %). The treadmill used was a Jaeger-HP Cosmos, model LE-600 C with a useful working surface of 250 x 75 cm and a safety system of side anchors and front and back guardrails. Pulmonary ventilation and respiratory gas exchange during exercise were measured directly with a Jaeger®, model Oxycon Champion, respiratory gas analyzer, with a breath by breath system, equipped with a two-way Triple-V® volume transducer. Heart performance was monitored with a 12 lead electrocardiograph and a Marquette®, model CASE 8000 stress test system and heart rate was monitored with a Polar Sport Tester®. The criterion used to confirm that the laboratory test was maximal was when the participant fulfilled at least two out of the following three conditions (based on Veeger el al, 1991): a) reaching a RER equal or higher than 1.0; b) a HR_{max} 10 beats lower than the theoretical maximum heart rate (220-age) and c) the manifest inability to continue the exercise.

Statistical analysis

The mean and standard deviation (*s*) were calculated for each of the variables both in the field test and in the laboratory for the three time points. All the variables passed the normality test. Pearson's correlation was used to study the relation between the variables in the field and the laboratory tests, with special emphasis on the distance covered in the field and the VO_{2peak} measured in the laboratory. The regression equation was also calculated for the estimation of relative VO_{2peak} from the maximum distance covered in the field, indicating the standard error of estimate (SEE). The statistical software used was SPSS (version 18.0 for Windows; Chicago, IL). The level of significance was set at $p<0.05$, although when it reached $p<0.01$ it was also stated.

RESULTS

The relation between the distance covered in the field test and laboratory variables

The results from the field test are shown in Table 2 and those from the laboratory test in Table 3 as mean results at each time point and for each player. In the field test the data on the distance covered were: 1562.7 m (s = 323.0), HR_{max} 179.2 beats·min^{-1} (s = 11.7), with a total time for the test of 11 min 01 s (s = 1 m 47s) and maximum velocity reached 11 km·h^{-1} (s = 0.8). In the laboratory test the values recorded for VO_{2peak} were 2.9 l·min^{-1} (s = 0.4), 40.6 ml·kg^{-1}·min^{-1} (s = 7.2), HR_{max} 182.2 beats·min^{-1} (s = 12), with a total time for the test of 10 m 4 s (s = 1 min 57 s) and 10.92 km·h^{-1} (s = 1.0) the maximum velocity attained.

TABLE 2
Field test average results per player.

Player	Time (m:s)	HR (beat:min)	Max. Velocity (km·h^{-1})	Distance (m)
1	7:55	162	9.7	1017.3
2	10:19	196	10.7	1428.0
3	12:26	189	11.7	1820.0
4	12:09	181	11.5	1764.0
5	10:22	175	10.5	1428.0
6	10:41	169	10.8	1493.3
7	13:18	183	12.2	1988.0
Mean	11:01	179.2	11.0	1562.7
SD	1:47	11.7	0.8	323.0

TABLE 3
Laboratory test average results per player.

	Ventilation (l·min^{-1})	VO_{2peak} (l·min^{-1})	VO_{2peak}/kg (ml·kg·min^{-1})	RER	HR (beats·min^{-1})	Time (min:s)	Velocity (km·h^{-1})	Slope (%)
1	78.2	2.7	31.4	1.2	158.0	6:55	9.4	1.6
2	107.6	2.4	38.6	1.4	193.7	8:35	10.3	1.5
3	111.4	2.9	43.6	1.3	189.7	11:04	11.5	2.3
4	136.6	2.5	51.2	1.5	188.0	12:35	12.3	2.5
5	201.1	3.2	35.1	1.4	183.3	9:33	10.7	2.0
6	142.8	3.0	36.4	1.3	176.3	9:46	9.5	2.2
7	150.1	3.6	47.9	1.4	186.3	11:57	11.9	2.4
Mean	132.6	2.9	40.6	1.4	182.2	10:04	10.9	2.1
SD	39.1	0.4	7.2	0.1	12.0	1:57	1.0	0.4

As can be seen in Table 4, the correlation between the data recorded in the shuttle run field and the laboratory tests are above r = 0.80 ($p<0.01$) for the variables common to both of them (time taken, maximum HR and distance covered in the field). The value for $VO_{2peak\text{-}field}$ (Léger et al., 1988) calculated from the distance covered in the field was 38.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (s = 4.7) which revealed a relation of r = 0.768 ($p<0.01$) with VO_{2peak} measured in the laboratory.

Validity of the field test

Using the relation (r = 0.854, $p<0.01$) between relative VO_{2peak} measured in the laboratory (40.59 $ml \cdot kg^{-1} \cdot min^{-1}$; s = 6.92) and the distance covered in the field test (1562.67 m, s 323.96) the regression equation was calculated for the estimation of relative VO_{2peak} from the maximum distance covered in the field test (Figure 1) being: X (VO_2 max, $ml \cdot kg^{-1} \cdot min^{-1}$) = 12.059 + 0.01826 Y (Distance covered, m), SEE = 0.03. The coefficient of determination explains 73% of the common variance of both variables.

TABLE 4
Pearson product-moment correlation between field and laboratory tests variables.

	r	**p**
Distance (m) – $VO_{2peak\text{-}lab}$ ($ml \cdot kg \cdot min^{-1}$)	0.854	0.000
Distance (m) – $VO_{2peak\text{-}lab}$ ($l \cdot min^{-1}$)	0.413	0.063
Distance (m) – $VO_{2peak\ Leger}$ ($l \cdot min^{-1}$)	0.901	0.000
$VO_{2peak\ Leger}$ ($l \cdot min^{-1}$) – $VO_{2peak\text{-}lab}$ ($ml \cdot kg \cdot min^{-1}$)	0.768	0.010
Time field – lab (min:s)	0.827	0.000
HR_{max} field – lab ($beats \cdot min^{-1}$)	0.850	0.010
Maximum velocity field – lab (($km \cdot h^{-1}$)	0.684	0.001

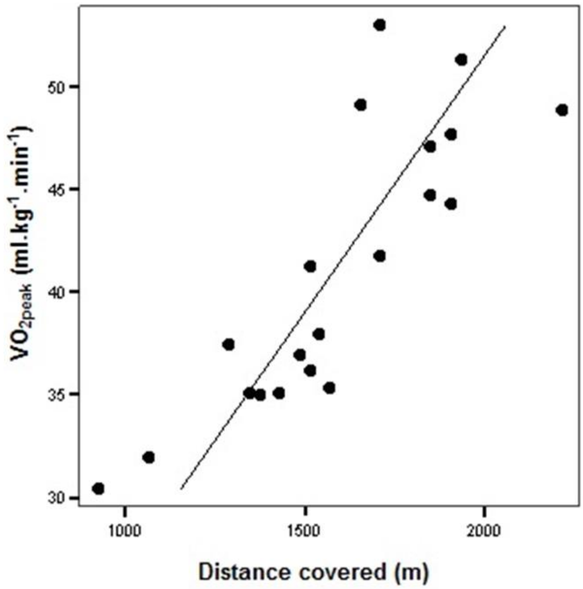

FIGURE 1: Relationship between VO_{2peak} (ml·kg·min^{-1}) and distance covered (m); ($r=0.854$. $p<0.01$).

DISCUSSION AND CONCLUSIONS

The main purpose of this study was to develop a valid field instrument to predict maximum aerobic capacity in top performance WBP with reference to a laboratory ergospirometric test using their own wheelchairs. The aerobic capacity of WBP is one of the parameters which determine performance level in this sport (Bernardi et al., 1999; Goosey-Tolfrey & Tolfrey, 2008). The benefits of using this type of test is evident for wheelchair sports like basketball, rugby or tennis (classical sports in an indoor version, Vanlandewijck et al., 2006), especially for the first two team sports, as it allows the evaluation of several players at the same time in the respective sports facility and with a minimum of equipment. The main findings of this study were three fold: a) there was a significant correlation between the variables studied in the field and the laboratory for each player, especially in relation to HR, velocity and duration of the test; b) the distance covered in the field test shows a significant correlation with VO_{2peak} (ml·kg^{-1}·min^{-1}) measured in the laboratory and c) the regression equation from the above relation can be derived to estimate VO_{2peak} from the distance covered.

The designed field test was based on the previous work of Vanlandewijck et al. (1999) with WBP, as well as that of Léger & Lambert (1982) and Léger et al. (1988) with populations without disability. The aim was to facilitate its administration to WB teams with a minimum of equipment and using available resources, so that the distance to be covered was extended to 28 m thus permitting the use of the lines and marks of an official basketball court. However to our knowledge only two studies have investigated the suitability of this test specifically for top performance WBP (Vanlandewijck et al, 1999; Goosey-Tolfrey & Tolfrey 2008). Also, one mayor advantage of this test is the possibility to assess a group of WBP at the same time and in the sport-specific context, which provides a clear realistic context, and usable features for in training administration (Goosey-Tolfery & Leich, 2013).

The data on VO_{2peak} obtained in the laboratory test (40.6 ml·kg^{-1}·min^{-1}, ±7.2) are higher than those found for elite WBP (Coutts, 1990, 1995; Veeger et al., 1991; Rostein et al., 1994; Schimd et al., 1998; Knechtle & Köpfli, 2001; Goosey-Tolfrey, 2005; Goosey-Tolfrey & Tolfrey, 2008). From our point of view, this is due to the high performance level of our sample. However, the rest of the variables in this test (see Table 3) coincide with other studies on top performance WBP.

For the variables obtained in the field, the results of the distance covered (1562.7 m; *s* 323.0) are not comparable with any other previous study mentioned due to the disparity of the protocols used. In the pilot test our initial velocity was fixed at 5 km·h^{-1} based on the proposal of Vanlandewijck et al. (1999), but we found that this was not a sufficient load for this sample and made the test excessively long (more than 15 minutes). To adapt it to the wheelchair and duration of approximately 12 minutes, initial velocity was established at 6 km·h^{-1}. Goosey-Tolfrey & Tolfrey (2008) established an initial velocity of 8.5 km·h^{-1}, but did not include data on the duration of the test in that study. In this way the mean duration of the field test was 11 min 01 s (*s* = 1 m 47), with a range between 7 min 55 s and 13 min 18 s, so that both the initial velocity and the duration of the test were adapted to the level of the sample studied and the duration recommendations for this type of test.

With reference to the setting, we coincide with Vanlandewijck et al. (2006) on the importance of clearly defining the conditions for carrying out the field test, as they considerably affect the results. When this is not done very disparate results can be produced among the protocols used due to small modifications in their administration which appear of no apparent significance but which, in our experience, can definitely skew the test. Two clear examples are the radius of the turn when reaching the line and the type of surface used. Performing this test requires doing 180º turns after a linear course of 28 m, which implies continuously accelerating and decelerating. After the pilot study, three meter wide lanes were marked out with cones on the end lines and each player had to turn within this space. Without this limitation of space and due to the increase of speed with each minute, the players began making 180º turns of larger and larger radii so as not to lose inertia, ending up by making a large circle around the track which increased the distance covered and thus compromised the suitability of the test. These conditions related to the turning radius were also considered by Vanlandewijck et al. (2006), who in their study determined the value of three times the width of the subject's wheelchair.

In this regard Vanderthommen et al. (2002) designed a field test using a protocol also based on the work of Léger & Boucher (1980), and defined an octagon in order to avoid the 180º turns, beginning at a velocity of 6 $km \cdot h^{-1}$ with increases of 0.37 $km \cdot h^{-1}$. This study does not cite the results with regard to the duration of the test, however the data recorded on the exercise stages show a high correlation with VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$) measured using a portable gas analyzer during the test ($r = 0.77$, $p<0.05$). Nonetheless, in our opinion this test is less specific to WBP as it does not involve the 180º turns and the linear courses that are common to this sport.

The surface on which the test was performed in this study was linoleum, and the wheelchair tyres were maximally inflated. Vanlandewijck et al. (2006) have reported a significant impact on shuttle run tests depending on the variation of the surface and the player-chair relation, a variable not controlled in this study. Neither was the resistance to friction determined in the field test or the laboratory test. In this line of thought Léger & Lambert (1982) found no differences in their regression equations as a function of the surface used; however, this friction may be different when using a wheelchair compared to running, as in the first case here is always contact with the ground while in the second there is a flight phase, so that extrapolations from one population to another should be made with caution (Vanlandewijck et al., 2006).

In turn, VO_{2peak} estimated from the proposed equation showed a better correlation with $VO_{2peak\text{-}lab}$ ($ml \cdot kg^{-1} \cdot min^{-1}$) than when calculated using the equation of Léger et al. (1988) (0.854 versus 0.796, $p<0.01$), which was designed for populations of adults of about 35 years old performing running tests, showing the specificity of the test designed for the population studied in this project. To our knowledge, only Vanlandewijck et al., (1999a) have evaluated WBP on the basketball court using a maximum continuous incremental test (shuttle run as proposed by Léger & Lambert, 1982) without using additional equipment. In the first study (1999a) these authors found a correlation of $r = 0.64$ between the distance covered in the field test (5 $km \cdot h^{-1}$ + 0.5 km every minute over 25 m.) and the VO_{2peak} recorded in an arm cranking ergospirometric test ($n = 20$). Surprisingly these authors found a higher correlation between this VO_{2peak} and other anaerobic type tests like the 30´´ anaerobic test ($r = 0.89$) or a 20 m sprint test ($r = -0.84$). We believe that the low correlation was due to the use of the VO_{2peak}, obtained in an arm cranking type laboratory test where the real motor pattern or technique of propelling the wheelchair in the field test was not faithfully reproduced in the laboratory test. This aspect was taken into account when the protocol and the anchoring system for the treadmill type ergometer were designed for this study so that the players could use their own wheelchairs. We believe that it is necessary to reproduce the specific motor pattern of the sport in the laboratory tests to ensure the validity of the results obtained.

The results of the application of the equation proposed in this study confirm its validity for predicting VO_{2peak} from the distance covered in the field test. This was not achieved in previous studies (Goosey-Tolfrey & Tolfrey, 2008) perhaps due to the use of an equation proposed for populations who covered the distance by running. However, we coincide with the previous authors in that the distance covered in the field test depends on the functional classification of the player. In our case the data were evident: Spearman's correlation between functional classification and the distance covered in the field was r = 0.5 ($p<0.05$) and r = 0.8 ($p<0.01$) for $VO_{2peak-lab}$ ($ml \cdot kg^{-1} \cdot min^{-1}$).

In conclusion, the findings of this study confirm the specificity of the shuttle run type test for WBP as it faithfully reproduces the demands of the sport, provides reliable data on HR, test duration and distance covered and is a valid predictor of VO_{2peak} as an indicator of aerobic performance in elite players.

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