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DEFENSIVE TWO-STEP TEST IN HANDBALL PLAYERS: RELIABILITY OF A NEW TEST FOR ASSESSING DISPLACEMENT VELOCITY

Prueba defensiva de dos pasos en jugadores de balonmano: Fiabilidad de una nueva prueba para evaluar la velocidad de desplazamiento

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Abstract

The main purposes of this study were to determine the absolute and relative reliability of two-step test (TST) with a functional electromechanical dynamometer (FEMD) in the evaluation of body displacement velocity. Sixteen physically active male handball players volunteers (age 21.4 ± 2.1 years) participated in this study. A repeated-measurement design was used to evaluate body displacement velocity with 15% and 30% of body weight overload (BWO). The mean velocity of the three highest repetitions and the peak velocity for the concentric contractions were taken to calculate the body displacement velocity. Reliability was assessed by t-tests of paired samples with the effect size (ES), the coefficient of variation (CV), standard error of measurement (SEM), and the intraclass correlation coefficient (ICC), with 95% confidence intervals. The absolute reliability provided stable repeatability for the 15% BWO protocol for mean velocity and for peak velocity in both protocols, with CV being below 10% in nearly all instances. The relative reliability of different velocity protocols to evaluate mean and peak velocity was acceptable (ICCs between 0.48 and 0.79). TST has acceptable reliability for the evaluation of the body displacement velocity in handball players using a FEMD.

Keywords: isokinetic, reproducibility, velocity, team handball, specific test.

Resumen

Los principales objetivos de este estudio fueron determinar la fiabilidad absoluta y relativa de la prueba de dos pasos (PDP) con un dinamómetro electromecánico funcional (DEMF) en la evaluación de la velocidad de desplazamiento. Participaron en este estudio dieciséis voluntarios varones jugadores de balonmano físicamente activos (edad 21,4 ± 2,1 años). Se utilizó un diseño de medidas repetidas para evaluar la velocidad de desplazamiento corporal con un 15% y un 30% de sobrecarga del peso corporal (SPC). Para calcular la velocidad de desplazamiento corporal se tomó la velocidad media de las tres repeticiones más altas y la velocidad máxima de las contracciones concéntricas. La fiabilidad se evaluó mediante pruebas t de muestras pareadas con el tamaño del efecto (ES), el coeficiente de variación (CV), el error estándar de medición (SEM) y el coeficiente de correlación intraclase (ICC), con intervalos de confianza del 95%. La fiabilidad absoluta proporcionó una repetitividad estable para el protocolo del 15% de SPC para la velocidad media y para la velocidad máxima en ambos protocolos, con un CV inferior al 10% en casi todos los casos. La fiabilidad relativa de los diferentes protocolos de velocidad para evaluar la velocidad media y la velocidad máxima fue aceptable (ICC entre 0,48 y 0,79). El PDP tiene una fiabilidad aceptable para la evaluación de la velocidad de desplazamiento en jugadores de balonmano utilizando un FEMD.

Palabras clave: isocinetico, reproducibilidad, velocidad, balonmano, prueba específica.

Introduction

Handball is a high-intensity intermittent sport in which the final actions, usually explosive, occur at a high velocity of movement (Kniubaite et al., 2019; Luteberget & Spencer, 2017; Manchado et al., 2013, 2021a; Michalsik, 2018; Starczewski et al., 2020). The presence of direct opposition requires that in addition to possessing a high technical and tactical level, velocity is a determining performance factor in the competition (Hermassi, Chelly, et al., 2019; Wagner et al., 2016). Knowing the factors that influence handball performance, will help us to develop evaluation tests that are of superior quality (Wagner et al., 2014), besides improving the coach's work, as we will know what the strengths and weaknesses of athletes are (Krüger et al., 2014).

Physical testing can be a valuable means of identifying an athlete's condition and assist in the optimal design of conditioning programs (Szymanski, 2013; van den Tillaar & Marques, 2011). Different authors have highlighted the importance of the evaluation of variables such as velocity and the ability to perform short duration and high-intensity physical actions as the main factors of physical performance in handball (Gonosova et al., 2018; Hermassi et al., 2015). The importance of specificity in the training and control of sports gestures has also been emphasized (van den Tillaar & Marques, 2011). In fact, it has been suggested that the closer the mechanical specificity of a training exercise is to performance, the greater the transfer produced (Appleby et al., 2020; Seitz et al., 2014).

However, paradoxically, to date, this evaluation has been carried out through non-specific tests that measure the different abilities through generic movements far from the reality of the game, such as the maximum velocity test (20m or 30m) that is usually used in handball (Hermassi, Chelly, et al., 2018). In addition, researchers that deeply analyze handball competition conclude that spriting displacements of such a long-distance hardly ever occur and that most of the displacements analyzed in this category are very short, below 2m (Luteberget & Spencer, 2017; Manchado et al., 2020). This implies the need to find mechanisms that allow the evaluation of these gestures naturally, extrapolating to other performance factors (Hermassi, Chelly, et al., 2018). It is true that knowing the velocity profile, either through laboratory tests such as the cycloergometer (Hermassi, Chelly, et al., 2018, 2019; Hermassi, Delank, et al., 2019) or the aforementioned field tests are useful to obtain data from the player, but they are also insufficient due to their non-specific nature.

Recently, a global test for handball called Game Based Performance (GBPT) has appeared, which is in line with the approach to the reality of the game and in which specific defensive and offensive actions are developed (Wagner et al., 2016, 2018, 2020). Although it is a very necessary and interesting contribution in the sense of applicability, they are global tests that do not discriminate a specific technical gesture, in which very short displacements are produced, such as the defensive exit to perform a marking in which the acceleration capacity of a player could be seen, a key action in handball performance.

Nowadays there is the possibility of analyzing specific gestures thanks to the appearance of new technological developments. These technological developments allow adapting to the real requirements of sports practice, such as functional electromechanical dynamometry (FEMD). FEMD emerges as a tool capable of, simultaneously, evaluating and training sports gestures, offering simply and intuitively, for the trainer, useful data on strength, velocity and power (Á. Rodriguez-Perea et al., 2021). The validity and reliability of the FEMD has been demonstrated in several previous studies under various conditions (Jerez-Mayorga et al., 2021; Martinez-Garcia et al., 2020; A. Rodriguez-Perea et al., 2019; Sánchez-Sánchez et al., 2021). For this reason, it would be useful to use the DEMF for the creation of a specific test that evaluates the velocity of short movements in a game gesture such as the defensive exit in handball. The defensive exit is a specific gesture in Handball that is usually done with one or two steps to avoid the displacement of the attacker through the marking.

For this reason, in this research a proposal is made for a new test called the "Two-Step Test" (TST). This test includes a free gesture in handball, seeking to make it highly automated and widely used in the game (i.e., defensive displacements, displacement actions prior to throwing, passing or feint) and to ensure the best familiarization, maximum reproducibility and reliability of the gesture (Bridgeman et al., 2016).

Therefore, the main purposes of this study were (I) to determine the absolute and relative reliability of TST with a FEMD in the evaluation of body displacement velocity and (II) to compare the absolute and relative reliability of mean velocity and peak velocity of body displacement velocity. The goal is to prescribe specific training loads for lower body. We hypothetised that velocity output will be task specific, and profiles would demonstrate inter-subject variability. Consequently, approaches that use non-specific measures to prescribe specific gestures would be associated with a degree of inaccuracy. To the best of our knowledge, this would be the first attempt to have a specific test with a free gesture in handball.

Materials & Methods

A repeated-measurement design was used to evaluate body displacement velocity with 15% of and 30% of body weight overload (BWO). After one familiarization session, participants attended to the court on two separate days (at least 48 hours apart) during a two-week period. On each testing day, participants completed different percentage of BWO protocols. Participants were asked to maintain their physical activity level during the assessment. All evaluations were conducted at the same time of the day (± 1 h) for each participant and under similar environmental conditions (~21ºC and ~60% humidity). The order of the percentages of BWO was randomly established. This order was carried out in the two testing sessions.

Participants

Sixteen professionals male handball players volunteers to participate in this study mean ± standard deviation [SD]: age 21.4 ± 2.1 years; body weight 69.2 ± 6.9 kg; height 1.70 ± 0.1 m; body mass index [BMI] 23.0 ± 1.6 kg/m^2 without any experience in isokinetic or dynamometers devices participated in this study. Participants were eligible for the study if they have: I) eight years of handball experience; II) no musculoskeletal injury; all participants were informed regarding the nature, aims and risks associated with the experimental procedure before they gave their written consent to participate. The study protocol was approved by the Institutional Review Board of the University of Granada (nº 350/CEIH/2017) and was conducted in accordance with the Helsinki Declaration.

Instruments

Height was measured to the nearest 0.1 cm via the stretch stature method with a wall-mounted stadiometer (Seca 202; Seca Ltd., Hamburg, Germany) with shoes and socks removed. Weight was measured to the nearest 0.1 kg using a mechanical beam scale (Seca 704, Seca Ltd., Hamburg, Germany). Body displacement velocity was measured with a FEMD (Model Dynasystem, Symotech, Granada, Spain) with a precision of 3mm for displacement, 100g for a sensed load, and a range of velocities between 0.05 m·s-1 to 2.80 m·s-1, coupled with a standard bench, an appropriate hip belt, a pulley system, and a subjection system.

Procedures

Familiarization Protocol

After anthropometrics assessments of body mass and height, each subject attended a 30-minute familiarization session with the FEMD. The familiarisation consisted of a general warm-up, consisting of five minutes of jogging, five minutes of joint mobility, and three sets of 20s of frontal and back movements. The general warm-up was followed by two sets of six repetitions with 15% of and 30% of BWO respectively and a free range of movement. A three-minute rest was established between sets.

Two-Step Test Protocol

Participants arrived in a well-rested condition at the start of each testing session. After the same warm-up as during the familiarisation protocols, participants rested for five minutes before the beginning of the test procedure and three minutes between each set. It consisted of two series of six maximum consecutive repetitions, with 15% and 30% of BWO with free range of movement. Participants had to perform a defensive tackle, the forward movement of holding an opponent in two-steps at the maximum possible velocity.

The initial position of the subjects was standing with their feet shoulder-width apart. When indicated, they had to perform a two-step forward movement, grabbing a person at the end of the concentric phase of the repetition, the final position of this phase was standing with the second leg that they moved advanced, and holding an "opponent" (Figure 1). In the eccentric phase of the repetition, they were told to return to the initial position in a controlled manner. Between each of the repetitions, five-second rest were allowed, and a correct initial position was verified by two evaluators. Both, the initial and final position of each repetition was previously established because of the own freedom of the movement. An appropriate belt was used to avoid being damaged when doing the forward steps. A free range of movement was established without taking any measures.

a)
b)
c)

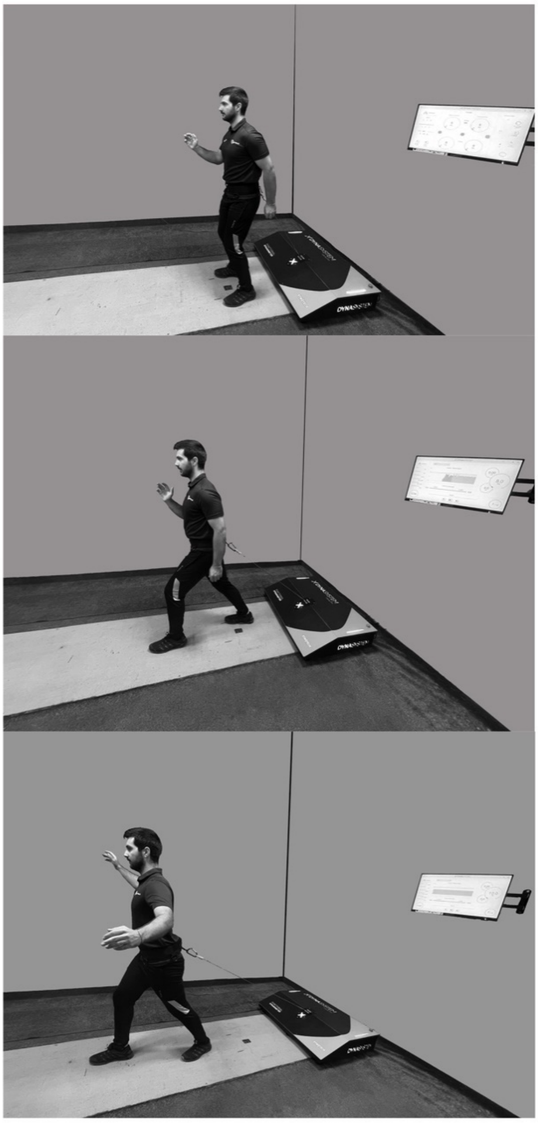

Figure 1. Defensive two-step test. a) Initial position, b) one step, c) two steps.

Statistical analysis

The normal distribution of the variables was confirmed by the Shapiro-Wilk test ($p > 0.05$). Reliability was assessed through paired-samples t-tests, Bland-Altman plots (systematic bias and 95% limits of agreement), Cohen's d effect size (ES), standard error of measurement (SEM), coefficient of variation (CV), and intraclass correlation coefficient (ICC; model 3.1). The ratio between 2 CVs (CVratio) was used to compare the reliability between the types of conditions (15% BWO mean vs. 30% BWO mean steps and 15% BWO max vs. 30% BWO mean max).

ICC values were interpreted following the scale of poor (less than 0.50), moderate (0.50 to 0.75), good (0.75 to 0.90), and excellent (> 0.90) reliability (Koo & Li, 2016). The scale used for interpreting the magnitude of the ES was specific to training research: negligible (< 0.2), small (0.2–0.5), moderate (0.5–0.8), and large (> 0.8) (Cohen, 1988). Meaningful differences in reliability were claimed when the CVratio was above 1.15 (Fulton et al., 2009). Reliability analyses were performed using a customized spreadsheet (Hopkins, 2015), while all other statistical analyses were performed using the software JASP software package (version 0.14.1. http://www.jasp-stats.org). Statistical significance was set at an alpha level of 0.05.

Results

The evaluation of the mean velocity of the concentric phase of two-step movement did not differ between the test and the retest ($p > 0.05$, ES < -0.01 with 15% of BWO and ES= -0.06 with 30% of BWO). Similarly, there was no significant difference between the test and retest of the peak velocity of the concentric phase with 15% of BWO ($p=0.499 > 0.05$, ES < 0.12) nor with a 30% of bodyweight overload ($p=0.832 > 0.05$, ES < 0.06).

The absolute reliability provided stable repeatability for the 15% BWO protocol for mean velocity and for peak velocity in both protocols, with CV being below 10% in nearly all instances. The relative reliability of different velocity protocols to evaluate mean velocity was good (ICC = 0.77) for 15% and 30% of BWO (ICC = 0.79) (Table 1). The relative reliability of different velocity protocols to evaluate the peak of body displacement velocity was good (ICC = 0.79) at 15 % and poor (ICC= -0.48) at 30% of BWO (Table 1).

Table 1. Test–retest reliability of mean and peak velocity measurements ($m \cdot s^{-1}$) provided by the FEMD at different percentages of body weight overload (n=16).

		Test ($m \cdot s^{-1}$)	Retest ($m \cdot s^{-1}$)	*p-value*	ES	CV (95% CI)	ICC (95% CI)	SEM (95% CI)
15% BW	Mean	1.6(0.2)	1.6(0.2)	0.977	-0.01	5.12.(3.78-7.92)	0.77(0.46-0.91)	0.08(0.06-0.13)
	Peak	2.9(0.1)	2.9(0.1)	0.499	0.12	1.34(0.99-2.08)	0.79(0.49-0.92)	0.04(0.03-0.06)
30% BW	Mean	1.3(0.2)	1.2(0.2)	0.747	-0.06	6.19(4.57-9.58)	0.79(0.50-0.92)	0.08(0.06-0.12)
	Peak	2.9(0.1)	2.8(0.1)	0.832	0.06	2.81(2.07-4.35)	0.48(0.00-0.78)	0.08(0.06-0.13)

ES= Effect size; CV = coefficient of variation; ICC = intraclass correlation coefficient; SEM= standard error of the mean

The most reliable velocity manifestation (CV= 1.34 %) to evaluate the body displacement velocity was peak velocity with 15% of BWO condition (Table 1).

When the average CV was considered for reliability comparisons, it was observed in relation to the protocol the percentage load 15% of BWO (CV = 5.12%) was more reliable on average than 30% of BWO (CV = 6.19%) with a difference CV = 1.21, likewise in the maximum CV it was observed that 15% of BWO (CV= 1.34%) was more reliable than 30% (CV= 2.85%) with a difference CV=2.13.

Regarding the type of variables to choose, the peak velocity was more reliable than the mean in both cases analyzed. The 15% BWO peak (CV = 1.34%) was more reliable than the 15% BWO mean (CV = 5.12%) Reliable. Difference CV=3.82 in 30% BWO peak (CV=2.81%) is more reliable than 30% BWO average (CV=6.19%) with a difference CV=2.20". The Bland-Altman plots made with the average and peak velocity variables in the two conditions of 15% and 30% BWO present a low systematic bias (range = -0.008 to 1.388 m·s^{-1}) and random error (range = 0.05 to 0.11 m·s^{-1}) (Figure 2).

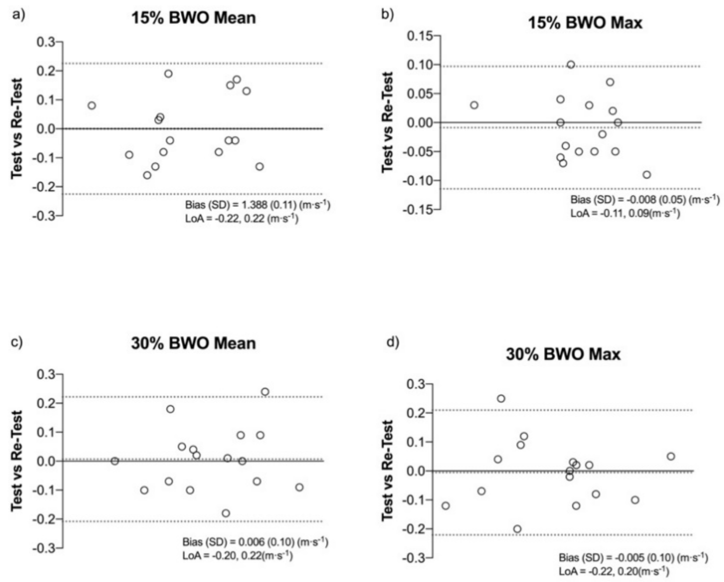

Figure 2. Bland-Altman plots. a) 15% BWO mean, b) 15% BWO max, c) 30% BWO mean, d) 30% BWO max.

Discussion

The main purposes of this study were (I) to determine the absolute and relative reliability of TST with a FEMD in the evaluation of body displacement velocity and (II) to compare the absolute and relative reliability of mean velocity and peak velocity of body displacement velocity. Among the main findings of the study, it is revealed that the two proposed protocols (15% and 30% of the BWO) present high absolute reliability below 10% of the CV and good relative reliability, there being a difference between the two types of the proposed protocol, the 15% of the BWO is presented as more stable. TST has acceptable reliability for the evaluation of the body displacement velocity in handball players using a FEMD.

The ICC measurement was good >0.75 for most of the treated conditions except for 30% of BWO max (Table 1), which means good relative reliability of the TST test. Although it can be interpreted that in the lower values of the relative reliability the ICC is affected by the inter-subject variability hiding good reliability if the inter-subject variability is large, even if the test-retest variability is low. For this reason, it was necessary to perform an absolute reliability study together with ICC. As is known, SEM and CV are not affected by intersubject variability as is the case with ICC (Weir, 2005b). Both values recorded were considered useful, being 10% of CV (Atkinson & Nevill, 1998).

In relation to the first objective, the reliability of the TST is good for measuring velocity in short displacements using a specific gesture. Specifically, the most reliable protocol type was the 15% BWO. This is a good approximation because as Simperingham et al. (Simperingham et al., 2016) pointed out in their literature review on the reliability of new technological developments for measuring travel velocity, there is a demand from sports to measure sprint performance over very short distances. In our case, we achieve this with the FEMD and, in addition, it can be directly associated with other variables that influence performance such as the measurement of strength and power. Simperingham et al. (Simperingham et al.,

2016) point out that velocity tests for team sports athletes should concentrate on short distances of less than 20m, in this sense most handball sprints are not performed in a straight line and often include one or several changes of direction (COD) during defensive and offensive actions (Daneshfar et al., 2018).

This statement is reinforced by research using motion analysis to understand the external demands of handball play, which has indicated the relative importance of short accelerations, with approximately 10% of all movements being of high intensity and short duration (Manchado et al., 2021b). In addition to this fact, most of the decisive interventions for the outcome of the game are based on these explosive actions (Manchado et al., 2020).

An aspect to highlight in this research is that, to the best of our knowledge, it is the first specific test for the evaluation of short displacements in handball. Therefore, it is impossible to establish direct comparisons with other similar studies. If there are other ways of evaluating the maximum velocity of displacement in a non-specific way or through field tests applied to handball such as the repeated sprint ability (Dello Iacono et al., 2016; Sabido et al., 2017) or the variant on this test which is the multi-directional repeated sprint ability (RSA) (Daneshfar et al., 2018). Some of these tests have demonstrated their applicability to training (RSM) (Dello Iacono et al., 2016) for their relation to power enhancement.

Analyzing the reliability of the tests used so far in handball velocity, the more general ones such as the 20m sprint test have given good reliability results, for example, Wagner et al. (Wagner et al., 2019) (ICC = 0.94, CV = 4%) and Sabido et al. (Sabido et al., 2017) (CV = 1.9%, ICC = 0.76). Concerning field tests such as RSM or RSA, Daneshfar et al. (Daneshfar et al., 2018) also found good reliability results (ICC range = 0.78 to 0.94).

The difference is that in these investigations it was about measuring the maximum velocity of long displacements and not the maximum velocity in short displacements, in a specific gesture, as is the case of this test. As Wagner says in the conclusions of his research on specific performance tests, the general performance and the specific performance of team handball are separate components (Wagner et al., 2019). In this regard, studies that have compared agility tests with sprinting ability have found that these are two independent locomotion movements (Salaj & Markovic, 2011). The same can occur with specific short displacements. Studies in this sense would be necessary once the reliability of the test has been proven.

With a similar intention to our research, there are other innovative proposals for specific strength training in handball that aim to obtain a positive transfer to particular gestures of the game. An example of this are the short movements, which use technology that favors eccentric strength work, or the velocity flywheels, which have demonstrated their effectiveness (Sabido et al., 2017). The latter have a limitation when it comes to measuring final performance, and that is that they use indirect forms and do not do so on the movement itself, as is the case in our study. In this sense, the reliability test performed in this more open test, using the flywheel to evaluate the average and maximum power, are acceptable (ICC = 0.79 to 0.93, CV = 7.5% to 13.2%), with similar results to those obtained in our research regarding reliability.

Recently a test battery that also seeks to find greater specificity has appeared in handball, the GBPT battery. In one of its tests that measures the capacity of specific agility in attack and defense with a technical action similar to that of our study, the reliability analysis was equally acceptable ICC above 0.70 and CV below 5% (Wagner et al., 2016). The difference with our case is that this agility test tries to measure the internal load and, in our case, the external one. Despite this, both use short gestures of displacement at maximum intensity using a specific skill.

These investigations demonstrate the need for specialists and coaches to find more similar resources to competition gestures to evaluate the game. In all cases, good forms of reliability are observed in these specific gestures. However, it is difficult to compare our study with the literature, since in none of the studies we found a sporting gesture that resembles the real gesture and that measures short displacement velocity.

The second objective of this study was to compare the absolute and relative reliability of mean velocity and peak velocity of body displacement velocity. Regarding absolute reliability, the maximum velocity showed lower CV% and SEM in the 15% and 30% BWO protocols. Regarding relative reliability, velocity maximum showed a higher ICC in the BWO protocol at 15% and lower in the BWO protocol at 30%. By comparing the maximum and mean velocity, we can confirm that the maximum velocity is the most reliable measure in the evaluation of body displacement velocity with the FEMD. The usefulness of these data is, in addition to comparing peak and average velocities, its knowledge, something difficult to see in previous studies, which is possible through new technologies such as FEMD.

There is a lack of studies on the peak and average velocity of movements or displacements of the center of mass in sport. Many of the studies that have evaluated the lower extremity in handball have done so during the time obtained in various tests in which different sprints were performed (Dello Iacono et al., 2016; Gorostiaga et al., 2005; Haugen et al., 2016). Other work has also recorded the time it takes to complete an agility circuit (Atalay et al., 2018; Hermassi, Chelly, et al., 2018; Kvorning et al., 2017). On the other hand, we find the use of GBPT to evaluate physiological capacities or several studies that measure the strength-velocity profile through a cycloergometer (Hermassi, Delank, et al., 2019; Wagner et al., 2016, 2019). In none by these cases is the velocity of body displacement assessed. In a study of Helland et al. (Helland et al., 2019) maximum velocity was evaluated in a 30-meter velocity test with various external loading protocols, and CVs below 2.4% were obtained. Hermassi et al. (Hermassi, Schwesig, et al., 2018) measured the maximum velocity and the velocity of the first 5 meters using a 30-meter sprint test (ICC = 0.97 and ICC = 0.96 respectively).In this sense, the ability to reach the maximum velocity in the shortest possible time is of vital importance for performance (Young & Rogers, 2014). This, together with the favorable reliability data found in our study and those mentioned above, leads us to affirm that maximum velocity is an appropriate indicator in the evaluation of the lower extremity in handball, as long as it is in a short time effort, as is the case with the TST. Therefore, lower extremity training programs should include exercises aimed at improving the maximum velocity in short duration actions.

This study has several limitations. It would be necessary to make a deeper familiarization since we are facing a completely new technology for all the study participants. Knowing that only two loading procedures have been used, it would be interesting once it is known that 15% of the load is more reliable and that around 30% of the gesture deforms a lot, to find at which percentage of the load this test is more reliable.

However, our study also has several strengths. It is the first study in which the reliability of a test of a specific handball action is verified. The results provide us with indications of increased reliability in future research to standardize the test. In addition, the advantage of our test over previous ones is that it is more specific, that it uses for the first time a game movement, and that it is evaluated with a DEMF device, a technological development, which allows combining different sensors, measuring at the same time other physical capacities such as strength, acceleration or power, and allows specific training work with the same test dynamics, modifying training variables, such as intensity or volume, which are key to performance.

In future research, it would be desirable to increase the sample size to achieve greater relative reliability (Weir, 2005a). The study could also be conducted in women and adolescents, as they may have different performance indicators and their performance on the test could vary the reliability of the test. Another option would be to study the reliability of new tests that specifically measure sports skills.

Conclusions

Despite the methodological limitations of the study, and considering the results obtained, we can conclude that the TST has good reliability for the evaluation of body displacement velocity in handball players. Similarly, we can affirm that the maximum velocity is more reliable than the average velocity and 15% of the body weight in which responds better when evaluating such displacements.

Practical applications

This study can serve as a preliminary step to research in which a particular training program is applied to improve lower extremity strength in handball in relation to body displacement velocity, especially in defensive actions. If we do not find greater reliability in studies with larger sample size, it would serve as a starting point to modify it and try to find a way to evaluate in a natural and freeway a specific gesture, such as the scoring action in handball. If such a device can be made available, coaches can know the velocity at which the gesture is effective and manipulate the loads in a variable way without affecting the velocity, resulting in improvements in the players' utility strength. Velocity can be an indicator of performance of the controlled natural gesture at which the load support is effective.

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