SIMPLE 'IN-WATER' VERTICAL JUMP TESTING IN WATER POLO

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Abstract:

The purpose of the present study was to develop a specific field test to assess accurately and reliably the ability of water polo players to perform a vertical jump in the water (in-water jump). Seventeen water polo players, competing in the Greek premier league, were tested at the vertical jump in the water and were measured in two ways; the first was in a laboratory with a 2-dimensional kinematic analysis (2D) and the other with a specific field test. The participants performed 3 trials for each procedure. The results for the field test were: for the first trial 67.6±6.0 cm, for the second 67.5 ±5.7 cm and for the third 67.4±5.6 cm. The mean value (68.6 ± 5.4 cm), with a range of 56.5 – 79.5 cm of the *in-water* jump, was assessed from the three best in-water trials. On the other hand, the mean value assessed on water for the vertical jump with the 2D kinematic technique was 65.3±5.9 cm. The results for the ANOVA with repeated measures showed no statistically significant difference between the three trials of the field test ($p<0.05$) and the best performance as measured with the 2D technique. The interclass correlation coefficient was found to range between 0.92 and 0.98 between the 3 vertical jumps of the field test, whereas the correlation between the evaluation of the best vertical jump from the field test and the best vertical jump assessed by the 2D video recording was 0.96. The reliability of the measurement was established with the method of Bland and Altman. The results indicate that the specific field test of the *vertical in-water jump* is a reliable method to assess the ability for the vertical jump in the water.

Key words: *in-water vertical jump, 2D kinematic analysis, field test*

DAS TESTEN EINES EINFACHEN 'IN-WATER' VERTIKALSPRUNGES IN WASSERBALL

Zusammenfassung:

Das Ziel dieser Forschung war, ein spezifischer Feldversuch zu gestalten, der die Fähigkeit von Wasserballspielern, den Vertikalsprung im Wasser (*in-water' jump*) auszuführen, genau und zuverlässig einschätzen würde. Siebzehn Wasserballspieler, die an den Wettbewerben in der ersten Liga teilnahmen, wurden getestet und auf zwei Weisen gemessen – die erste Messung wurde im Labor mittels einer zweidimensionalen kinematischen Analyse (2D) durchgeführt und die andere Messung wurde mittels eines Feldversuches realisiert. Den Teilnehmern standen für jede Messung drei Versuche zur Verfügung. Die Ergebnisse des Feldversuches waren: 67,6±6,0 cm für den ersten Versuch, 67,5 ±5,7 cm für den zweiten und 67,4±5,6 cm für den dritten. Der Mittelwert (68, 6 ± 5,4 cm) des *In-Water* Sprunges, mit der Spannweite zwischen 56,5 und 79,5 cm, wurde aufgrund von drei besten Versuchen eingeschätzt. Andererseits, der Mittelwert, eingeschätzt für den Vertikalsprung mittels der zweidimensionalen kinematischen Methode war 65,3±5,9 cm. Die Ergebnisse der Varianzanalyse mit wiederholten Messungen wiesen auf keinen statisch signifikanten Unterschied zwischen drei Versuchen beim Feldversuch ($p < 0,05$) auf und die beste Leistung bei der Messung mit der zweidimensionalen Methode. Der Interklassen-Korrelationskoeffizient variierte zwischen 0,92 und 0,98 zwischen drei Vertikalsprüngen beim Feldversuch. Die Korrelation zwischen der Bewertung des besten Vertikalsprungs beim Feldversuch und der Einschätzung des besten Vertikalsprungs mittels der zweidimensionalen Videoaufnahme war 0,96. Die Verlässlichkeit der Messungen wurde mittels der Methode von Bland und Altman bestimmt. Die Ergebnisse zeigten, dass der spezifische Feldversuch des *In-Water*-Vertikalsprungs eine verlässliche Methode zur Einschätzung der Fähigkeit, den *In-Water*-Vertikalsprung auszuführen, war.

Schlüsselwörter: *'In-Water', Vertikalsprung, 2-D kinematische Analyse, Feldversucht*

Introduction

The performance of the vertical jump constitutes a fundamental technical skill in many team sports including water polo, where a player very often has to move his body vertically out of the water in order to shoot the ball, or to prevent the opponent from shooting or passing the ball (Gladden & Colacino, 1978; Klinzing, 1991; Sanders, 1999; Dopsaj, 1999). For the goalkeeper vertical jumps are even more important as he has to jump frequently in order to save the attackers' shots (Smith, 1998; Platanou, 2002). The higher and more explosive the goalkeeper can jump from the water, the more chances he has to save his goal from either high or low shots or the ones directed to the corners of the goalpost. The same applies to the other players on a team who must jump at a very high level above the water surface to make a good shot or to stop the ball. Because of this utilities, the 'boost' is a skill that is often included in a daily training regimen, mostly for the goalkeepers and for the rest of players too. A test should therefore be found, that will examine this attribute of players. To date there is no sport-specific field test assessing accurately and reliably the capability of players to perform such boosts. The three-dimensional video graphic technique used by Sanders (1999) to study the kinematics variables contributing to height achieved in boosts necessitates, however, considerable laboratory infrastructure which is rarely available. The purpose of the present study was to develop a readily available, reliable and valid field test of in-water vertical jump specifically for use with water polo players.

Methods

Seventeen water polo players, competing in the Greek premier league, were tested performing vertical jumps in the water. The subjects were measured using two different methods; the first method was based on 2D kinematic analysis and the other on the proposed field test.

The subject's characteristics are demonstrated in Table 1.

Table 1. Subjects' characteristics

Characteristics	
Age (yrs) Height (cm) Weight (kg) Experience (yrs)	22.9± 2.1 186.9±4.6 87.3±7.2 10.2± 2.2

2D kinematic analysis

2D kinematic analysis was used to measure the vertical displacement of the player's head above the water surface. The BIOKIN 2D V 4.0 kinematics analysis system (Darras, 1985) was used to digitize the subject's vertical jump motion at 50 frames / per second. The participant performed three trials, starting from the basic flotation position to the highest point he could raise himself above the water surface. A SVHS video camera (Panasonic MS5, Japan) was placed on a stationary rigid tripod (50 Hz, 720X576 resolution) at 15 m distance from the performer. The camera was manually zoomed and focused in order to capture the full jumping motion in view (Bartlett, 1997). An automatic shutter was used. The camera recorded the sagittal plane of the subject's motion (Donnelly, 1990; Bloomfield, Ackland, & Elliot, 1994; Hamill & Knutzen, 1995). A scaling object of 1-metre length was used. The scale was placed in the plane of action before and after the subject's trials. The scale was floating on the water's surface. The scale was then digitized for video calibration and surface location. An easily identifiable black marker was attached at the top of the subject's cap. During the analysis, the distance between the marker on the subject's cap during flotation and the water surface was measured. Then the distance of the marker of the subject's cap at the highest point of the jump and the water surface was also measured. The difference between these two measurements gave the resulting vertical displacement during the subject's jump.

Specific field test

The field test employed in the present study has been previously described (Platanou, 2005). In detail the *in-water* vertical jump was assessed using a board with a centimetre scale attached to it. Its base was secured on the swimming pool gutter perpendicular to the surface of the water. The board was placed 120 centimetres above the water surface, in such a position as to taking care not to hinder the movement of the participants during their trials. The distance between the lower level of the board and the water surface was measured by a piece of string with a small weight attached to its end. The height of the board could easily be adjusted to maintain the distance constant. In order to record the trials of the players a SVHS video camera (Panasonic MS5, Japan) (50 Hz, 720X576 resolution) was placed facing the board approximately 3 m away from it. The measurement resolution on the board was 0.5 cm. From the fundamental floating position, the players, who were beneath the board, were required to move their bodies upward and touch the board with one hand, at the highest position that they could reach on three different occasions. Players, prior to the in-water jump, remained floating without vertical oscillations by utilizing mainly slight movements of the legs. In the average starting position the body was immersed to the acromion level under the surface of the water which resembled the basic position commonly adopted by players when not actively involved in the game. The subsequent video analysis was performed by freezing the image at the highest point of player's hand contact with the board. This allowed identification of the distance between the surface of the water and the highest point reached by adding the centimetres of the board trial to the distance of the water from the board (120 cm). From the total distance measured the length of the upper limb was subtracted. The water polo player in his fundamental float on the water is submerged in the water at shoulder height up to the point at which the joint of the upper arm begins (Figure 1). An intraclass correlation coefficient was calculated to determine the reliability of the *in-water* vertical jump performed three times in the field test. A one-way repeated measures analysis of variance (ANOVA) was used to determine if there was a statistically significant difference between the first, second and third scores achieved in the field test and the best performance measured with the 2D technique. Pearson's correlation coefficient was used to calculate the relationships between the best vertical jump among the three trials from the field test, and the best vertical jump from the 2D technique. Also, in order to ensure validity and reliability, the Bland and Alman (1986) plot between the two methods was used. The level of significance was set at $p<0.05$.

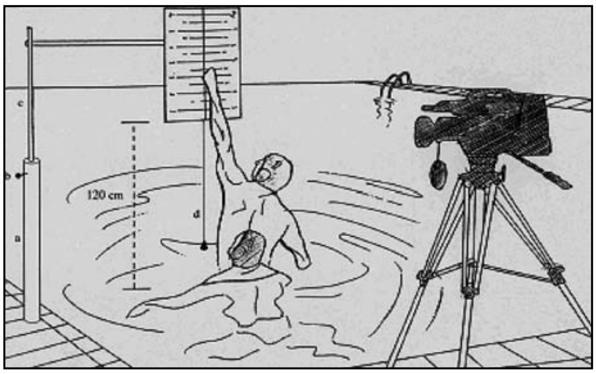

Figure 1. In-water vertical jump. Vertical pole consists of two parts (a and c). Part (c) could be extended upwards by adjusting the total height of the pole. a. Lower part of vertical pole. b. Vertical pin sliding into holes made on the upper pole. c. Upper part of vertical pole. d. A piece of string with a small weight attached to its end (plumb line).
With permition from T. Platanou (2005); J. Sports Med Phys Fitness, 45 (1): 26-31

Results

From the data (n=17), the mean values and standard deviations of the height of the jump measured with the specific test were: for the first trial 67.6±6.0 cm, for the second, 67.5 ±5.7 cm and for the third 67.4±5.6 cm. The mean value (68.6 ± 5.4 cm), with a range of 56.5 – 79.5 cm of the *in-water* jump, was assessed from the three best in-water trials, while the maximum height of the edge of the extented hand of the water polo players' jump reached an average value of 148.0±6.8 cm (range: 133 -161.50 cm). The mean value of the vertical jump measured whith 2D kinematic technique was 65.3±5.9 cm. The results of the ANOVA with repeated measures showed no statistically significant difference between the three trials of the field test ($p<0.05$) and the best performance of the measurement with the 2D technique. The interclass correlation coefficient was found to range between 0.92 and 0.98 between the 3 vertical jumps of the field test, while the interclass correlation coefficient between the best vertical jump from the field test and the best vertical jump of the 2D video recording was 0.96. The reliability of the measurement was established with the method Bland and Altman (1986) as shown in Figure 2 for the two tests.

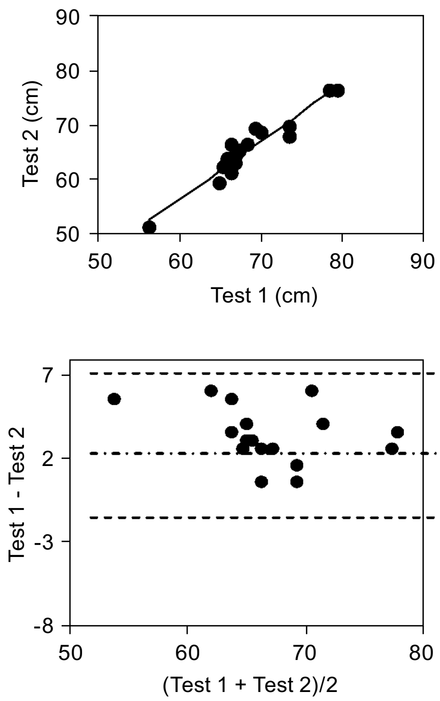

Figure 2. Regression and Bland and Alman plot for on-water polo jump determination.

Discussion and conclusion

Reliability

The test-retest results indicate that the specific field test of the vertical *in-water jump* is a reliable method of assessing the capability for the vertical jump in the water (r=0.92-0.98). The results of ANOVA with repeated measures showed no statistically significant difference between the three trials of the field test ($p<0.05$) and the best performance measured with the 2D kinematic technique. The fact that the mean values from the first to the third jump did not exhibit any statistically significant difference means that they were either not affected by fatigue or that there was no transferable learning effect during the performance of the three trials.

Validity

The validity of a field test can be determined by concurrently measuring field test performance and the criterion measure, and by statistically assessing the relationship between the test scores. The criterion method with a 2D kinematic technique is the measurement criterion of the vertical jump. It is a well-known and valid method which is broadly used. To date there is no sport-specific field test to assess accurately and reliably the capability of players to perform such boosts. The three-dimensional video graphic technique used by Sanders (1999) to study the kinematics variables contributing to height achieved in boosts necessitates, however, considerable laboratory infrastructure which is rarely available.

Seventeen water polo players performed the vertical jump and were measured with both a 2D kinematic technique and a field test in order to validate the vertical jump in the water. The 2-dimensional videoscopic method was used instead of the 3-dimensional since it is considered an adequate procedure for the movement of one point in a plane. The results of the vertical jump field test were then correlated with the height of the 2D kinematic analysis technique. A high corelation (0.96) was obtained between the two tests while no statistically significant difference was identified between the height of the vertical jump between the two trials (68.6 5.4 cm of the field test vs 65.3±5.9cm of the 2D kinematic technique). Also, this value was very similar to the one (71.0 ± 13.0 cm) reported by Sanders (1999), using three- dimensional video graphic techniques. The jumps' values of the water polo players in the water were higher compared to those out of the water (Platanou, 2005). This is probably due to the participation of the arms in the movement of the in-water vertical jump, in addition to the continuous water support. The jumps' height is more important for water polo players when the jump is executed with one arm extended in the upright position. The maximum height of the edge of the hand is about 1.5 m above the water. This means that the players can jump high and be in a position to block the ball or to receive it and shoot while attacking. This ability is dependent on kinematic factors (Sanders, 1999; Platanou, 2005). So far, the majority of studies have examined the above issue while focusing on the underwater motion (Davis & Blangsby, 1977; Eliot & Armour, 1988; Ball & Baker, 1996; Feltner & Nelson, 1966). However, Sanders reported, using a multiple regression model, that the squared maximum foot speed, the range of knee joint extension, and the starting trunk angle with respect to the horizontal accounted for 74% of the variance in height achieved in the water. In another study (Platanou, 2005) the relation between the jump in the water and the legs' explosiveness on a dry-land jump was examined and was found to be poor. An additional finding was that the players who practiced in-water iumps extensively, such as goalkeepers and top-level players, demonstrated a significantly better capacity to move their body out of the water when they were compared to players at different game positions and players of less expertise, respectively, in spite of performing similarly on dry land (Platanou, 2005). These findings reinforce those of the study by Sanders who showed that the performance of the in-water jump depends on technical skills rather than pure explosive power.

As seen by the method used by Bland and Altman (1986) in Figure 2, the field test is a valid and reliable measurement instrument and can be used by coaches to evaluate the capability of water polo players to move their bodies vertically out of the water.

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TESTIRANJE VERTIKALNE SKOČNOSTI 'IZ VODE' U VATERPOLU

Sažetak

Uvod

Izvedba vertikalnog skoka čini jednu od baznih tehničkih sposobnosti u mnogim timskim sportovima, uključujući i vaterpolo, u kojem igrač vrlo često mora tijelo izdizati vertikalno izvan vode kako bi uputio udarac na vrata ili kako bi u tome ili u dodavanju lopte spriječio protivnika (Gladden & Colacino, 1978; Klinzing, 1991; Sanders, 1999; Dopsaj, 1999). Danas još ne postoji za sport specifičan situacijski test kojim bi se precizno i pouzdano mogla procjenjivati sposobnost igrača da izvede takva podizanja iz vode. Kako bi ispitao koje kinematičke varijable doprinose postignutoj visini potrebnih vertikalnih pomaka, Sanders (1999) je koristio trodimenzionalnu grafičku video tehniku. Međutim, takva laboratorijska infrastruktura rijetko je dostupna. Svrha ovog istraživanja bila je kreirati novi terenski test koji bi bio lako dostupan u svim uvjetima.

Metode rada

Ispitanici. Sedamnaestorica vaterpolista, natjecatelja grčke prve vaterpolske lige, testirana su u izvođenju vertikalnog skoka iz vode. Koristile su se dvije različite metode mjerenja; prva se temeljila na dvodimenzionalnoj kinematičkoj analizi, a drugu je činio specifičan terenski test.

Instrumenti. Tehnika dvodimenzionalne kinematičke analize omogućila je mjerenje promjena u igračevoj visini, što se procjenjivalo od površine vode do vrha tjemena igrača. Koristio se računalni program BIOKIN 2D V 4.0 (Darras, 1985) i digitalizirana kinematička analiza u okviru 50 sličica u sekundi. Za vrijeme testiranja izvedba vertikalnog skoka iz vode procjenjivala se pomoću ploče s pričvršćenom centimetarskom skalom. Njena je baza bila učvršćena za rub bazena okomito u odnosu na površinu vode. Ploča se izdizala 120 cm iznad površine vode, a vodilo se računa da u tom položaju ne ometa ispitanike za vrijeme njihovih izvedbi. Udaljenost između donjeg ruba ploče i površine vode mjerena je komadom uzice na čijem je kraju bio zavezan mali uteg. Visina ploče lako se mogla prilagoditi kako bi se ta udaljenost zadržala konstantnom. Za snimanje svih izvedaba igrača korištena je SVSH video kamera (Panasonic, MS5, Japan) (50 Hz, rezolucija 720x576) koja je bila okrenuta prema ploči i smještena na udaljenosti od otprilike 3m od ploče. Rezolucija mjerenja na ploči bila je 0,5 cm.

Postupak. Iz osnovnog plutajućeg položaja, igrač, koji se nalazio točno ispod ploče, imao je zadatak podići svoje tijelo iz vode prema gore i dotaknuti ploču jednom rukom na najvišoj poziciji koju je mogao dohvatiti. Svaki je igrač zadatak izvodio tri puta. Igrači su prije samog skoka plutali na vodi bez vertikalnih oscilacija, koristeći se pri tomu samo laganim pokretima nogama. U prosječnoj startnoj poziciji tijelo je bilo uronjeno u vodu do razine acromiuma, što odgovara osnovnoj poziciji koju igrači zauzimaju u vodi dok nisu aktivno uključeni u igru. Video analiza provodila se pomoću zamrzavanja slike u najvišem položaju igrača u trenutku kada je ruka bila u najvišem kontaktu s pločom. To je omogućilo identifikaciju udaljenosti između površine vode i najviše dosegnute točke pomoću pribrajanja centimetara na ploči udaljenosti između ploče i površine vode (120 cm). Od ukupne izmjerene udaljenosti oduzeta je duljina ruke. Vaterpolist je u svojoj osnovnoj poziciji u vodu uronjen do visine ramena, do točke u kojoj počinje zglob gornjeg ekstremiteta.

Metode za obradu podataka. Kako bi se procijenila pouzdanost vertikalnih skokova, izvedenih u tri navrata, primijenjenim situacijskim testom izračunat je koeficijent korelacije između pokušaja. Jednosmjerna analiza varijance za ponovljena mjerenja (ANOVA) korištena je kako bi se utvrdilo postoji li statistički značajna razlika između prvog, drugog i trećeg skoka i najbolje izvedbe utvrđene uz pomoć mjerenja 2D tehnikom. Pearsonov koeficijent korelacije koristio se za izračunavanje povezanosti između najboljeg vertikalnog skoka od tri izvedena i najboljeg vertikalnog skoka procijenjenog kriterijskim testom vertikalne skočnosti iz vode. Također, kako bi se provjerila valjanost i pouzdanost mjerenja, korišten je Blandov i Aldmanov (1986) grafički prikaz odnosa dviju korištenih metoda. Razina značajnosti definirana je kao $p<0.05$.

Rezultati

Na temelju prikupljenih podataka (N=17), dobivene su sljedeće aritmetičke sredine i standardne devijacije visina skokova, izmjerenih specifičnim testom vertikalne skočnosti iz vode: za prvi pokušaj 67,59 ± 6,04 cm; za drugi pokušaj 67,53 ± 5,71 cm i za treći pokušaj 67,41 ± 5,64 cm. Prosječna vrijednost (68,65 ± 5,38 cm), u rasponu od 56,5-79,5 cm skoka iz vode dobivena je na temelju najbolja tri pokušaja. Maksimalna visina vrha ispružene ruke u skoku vaterpolista iznosila je 148,0 ± 6,8 cm, (raspon: 133 - 161,5 cm). Prosječna vrijednost vertikalnog skoka izmjerenog pomoću dvodimenzionalne kinematičke tehnike iznosila je 65,32 ± 5,93 cm. Rezultati analize varijance za ponovljena mjerenja (ANOVA) nisu pokazali statistički značajne razlike između različitih pokušaja u okviru terenskog testa ($p> 0.05$) i najbolje izvedbe dobivene na temelju mjerenja tehnikom2D. Koeficijent korelacija između tri vertikalna skoka iznosio je između 0,92 i 0,98, dok je koeficijent korelacije između visine najboljeg vertikalnog skoka izmjerenog terenskim testom i najboljeg vertikalnog skoka izmjerenog dvodimenzionalnim snimanjem iznosio 0,96. Pouzdanost mjerenja utvrđena je metodom Blanda i Altmana (1986).

Zaključak

Dobiveni rezultati pokazuju da se opisani specifičan terenski test *vertikalni skok iz vode* pokazao pouzdanom metodom za procjenu sposobnosti vertikalne skočnosti iz vode (r= 0,92-0,98).