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International Journal of Current Research
Vol. 6, Issue, 05, pp.6675-6680, May, 2014

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

COMPARING PHYSICAL CAPACITIES AND HANDBALL MATCH DATA AMONG ELITE BACK AND FRONT PLAYERS IN SOUTHERN-REPUBLIC OF BENIN

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ARTICLE INFO

Article History:
Received 07th February, 2014
Received in revised form
16th March, 2014
Accepted 19th April, 2014
Published online 20th May, 2014

Key words:
Handball,
Match,
Playing position,
Physical test,
Republic of Benin.

ABSTRACT

The objective of this study was to compare the physical capacities and the match physiological data of back players with those of front players, belonging all to the handball elite of the Republic of Benin. The study sample included 17 players (23.52 ± 0.79 years) with 9.5 ± 0.5 years of competition handball practice. For an experimental match, they were randomly separated in two teams (A and B), each of which included back players (BP) and front players (FP). The main data were the playing positions (BP and FP) and the results of the following tests: 30 m isolated sprint (S30), repeated-sprint ability (RSA), squat jump (SJ), counter movement jump (CMJ), physiological match data, body mass index (BMI), as well as heart rate (HR). The results of BP were better than those of FP for RSA ($p < 0.01$) and the distance covered in match ($p < 0.05$). This study provides the first analysis as well on the physical and physiological parameters as on the match data in Beninese elite handball players, according to their playing position. The results suggest that the physical and anthropometric characteristics should be included in any testing process of young handball players in the Republic of Benin. This could be added to the data of the literature and contribute to talent identification and development.

INTRODUCTION

A handball match is characterized by a succession of short and intense actions, intersected with periods of incomplete recovery (Buchheit, 2005). Whatever the playing position, performance in handball depends on the players' technical skills, the anthropometric characteristics, the physical and physiological capacities (Buchheit*et al*., 2009). Each playing position corresponds to specific anthropometric, physical and technical profiles which contribute to the performance of the whole team. Therefore, the achievement of good performance during a handball match depends, *inter alia*, on the way in which the player's individual characteristics are integrated into the collective project. Anthropometric data and physical performance have been compared in handball professionals, at different positions. Research has shown the existence of a close connection among studied parameters (Krüger*et al*., 2013; Sibila and Pori, 2009; Rogulj*et al*., 2005). In the same direction, handball players presented differences related to the playing positions, with regard to the anthropometric parameters (Needhiraja and kaalidasan, 2010). It was the same for the results in aerobic and anaerobic capacities (Chelly*et al*., 2011; Koç, *et al*., 2011). A study of the effectiveness of shots in attack has shown differences related to the playing positions of high level handball players (Moncef*et al*., 2012). From all this, it appears that handball is a physiologically very demanding activity, the requirements of which are specific to the playing positions of international elite. That is why trainers should seek to maintain the effectiveness (offensive and defensive) of the players throughout a match, putting a stress at the same time on the development of the necessary skills during training sessions. Periodic evaluation of the relations between physical capacity and physiological match data according to position in handball players should also be undertaken as is the case in football (Randers *et al*., 2010; Di Salvo*et al*., 2007). Studies with senior handball players are rather scarce (Pontaga and Zidens, 2012; Ziv and Lidor, 2009). In the context of the Republic of Benin, all players and leaders aspire to high performance, without setting up the adequate strategies for talent detection. Better, the organization of training appears not very rational, since all the players do often carry out the same exercises at the same rate. Moreover, the development of muscular capacities does not constitute a major concern, when the players leave the junior category. Under these conditions,

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one must undertake a diagnostic evaluation, in order to achieve a complete description of the situation. Such an evaluation should integrate anthropometric and physiological factors as well as match data, in order to highlight the differences between the Benin players, according to their playing positions. It will be based on the assumption that physical capacities and match data are similar in the Benin back and front players who represent the study sample. Since the results of such work are not yet available, this study was undertaken to compare the physical capacities and the physiological match data of senior front players with those of back players belonging all to the Beninese handball elite.

MATERIALS AND METHODS

Experimental approach

It was an intervention study, aiming at highlighting the differences of capacities, physical performances, and physiological data between back and front handball players during a match. One week before the match, the data-collection began with anthropometric measurements, the single 30 m sprint test, and the RSA test, followed by the 30-15 IFT. Before these tests and measurements, the players rested for at least 72 hours, i.e. without involving in physical or sportive activity. On the day of the match, the first blood and urine sampling took place at least 15 min before the jumping tests and prior to the match, and the second sampling took place just at the end of the match. At least 10 min after warming up, each player carried out the tests of squat and counter movement jumps (Fig 1). All the players had consumed their previous meals more than three hours before the match. Blood was drawn at the cubital fold of the left elbow, urine was collected by each player in two tubes which were given to him as soon as he arrived. Blood samples were centrifuged at 3000 rounds during 10 min, within the hour following the collection. Serum was then preserved in aliquoted tubes at the temperature of-8 °C before analysis. Blood lactate was assayed on left finger, by micro-sampling.

Study sample

A non-probabilistic sample made up by reasoned choice was used to carry out this study. It included 17 handball players, selected among the international volunteer juniors and seniors who usually take part in the Division 1 (D1) championship of the Republic of Benin. To be included in the study sample, each of the players were asked to:

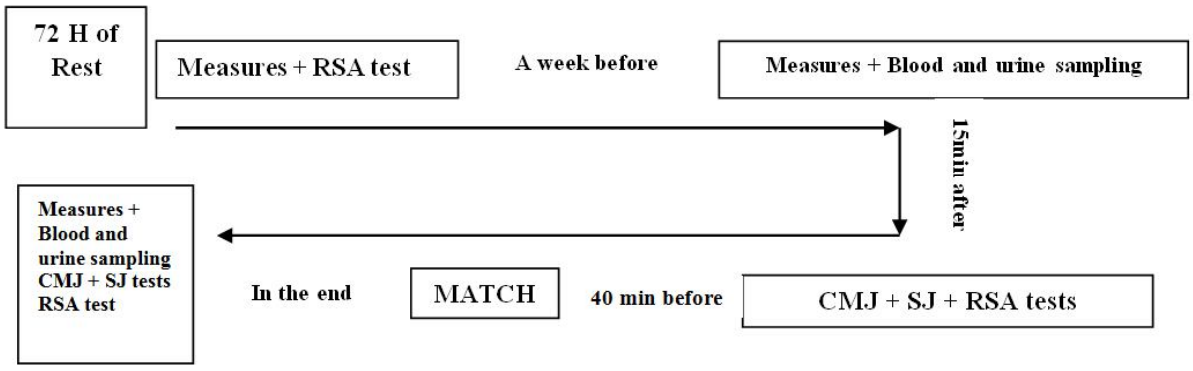
- hold a sportive licence whose validity is attested by their participation in the D1 championship of the current season;
- be between 18 and 34 years old;
- have a seniority of at least five years in the handball competition practice, and a weekly training time of six hours or more.

Their two hours' training sessions are made up of traditional handball exercises, i.e. passes, shots, one on one and other specific drills, counter-attack boots and global game on the court.

Initially gathered by playing position, i.e. back players (left and right back and half-centre) and front players (left and right wingers and pivots), they were then randomly separated in two teams (A and B), each of which included front and back players for the experimental match. To take part in this study, all the players gave their written informed consent. The study was approved by the Scientific Committee of Sciences and Technics of Physical Activities and Sports (STPAS) of the University of Abomey-Calavi, setting as Ethics Committee.

Materials and Technics

A stadiometer and an electronic scale (9000 Salter, China), were used respectively to measure height to nearest 0.5 cm and body weight with to nearest 100 g. FT4 heart rate monitors (POLAR, Finland) were used to measure the resting heart rate and that of the match, the total distance covered, as well as the energy spent by each player during the match. A spectrophotometer RT-9200 (RAYTO®, Germany) was used



RSA : repeated-sprint ability ; CMJ : counter movement jump ; SJ : squat jump ; Measures : anthropometric and rectal temperature measures ; H : hour.

Figure 1.Synthesis of the chronological steps of the study design

for blood glucose assays, using the final point method. A clinical refractometer Sur-Ne (ATAGO, Japan) made it possible to determine the urinary specific gravity (USG). Blood lactate was assessed before and at the end of the match (during the last five minutes, the players in each team left one by one, alternatively) with a lactometer (Lactate Pro, Urkray, Japan). The race speed in the single 30 m-sprint and repeated-sprint ability (RSA) were measured with photo cells (BROWER TIMING SYSTEM, USA). The OptoJump Next device (MICROGATE, Italy) was used to measure the heights in squat jump (SJ) and counter movement jump (CMJ). A tape reader DVD/CD and a pre-recorded disc of the 30-15 IFT (Buchheit, 2005) were used to assess the maximum oxygen consumption on the field. Rectal temperature was measured by digital thermometers (MT 101R, HangzouSejoy, China). A multifunction Meteostar device (thermometer, hygrometer and altimeter) was used to measure the ambient temperature during the match.

Experimental match

The match was played outdoors between 4 and half past 5 p.m., at an ambient temperature varying from 34.6 °C to 35.4 °C, and the relative humidity from 68% to 70%, with respect to the prescribed time (IHF, 2010), i.e. two half-times of 30 min separated by a break of 15 min. At the beginning of the match, two water cans of 1.5 L, marked with their respective names were given to the players for their hydration. Just in the end, the quantity of water drunk by each player was calculated by subtracting the remaining water volume from the initial quantity that was given to him.

Physical tests

- The 30-15 IFT used, is an intermittent and maximum field test, made up of periods of 30 s race, intersected with periods of active 15 s recovery, validated for handball players (Buchheit, 2005). The maximum aerobic speed (MAS) and the $VO_2max_{30\text{-}15IFT}$ were estimated in each player from the number of stages completed.
- For the test of single 30 m- sprint, each player was asked to run at maximum speed on the distance of 30 m, for three boots separated by 30 s. The best performance (in seconds) was recorded.
- The repeated-sprint ability (RSA) test used in this study consisted in carrying out six shuttle sprints at maximum speed, on 15 m x 2, with 14 s of active recovery between two races (Morin *et al*., 2011). The criteria of performance appreciation were the average time of race (Ta), i.e. the running time cumulated during the six race boots on 15 m x 2 divided by six expressed in seconds and the fatigue index (FI) for the six races, expressed as percentage. FI = (average time/ideal time) ×100 – 100. The ideal time is the best time multiplied by six.
- At the squat jump, the player was asked to jump the highest possible, starting from a motionless position of the knees at 90°, with the hands on the hips. During the counter movement jump, each player initially realised a fast inflection of the knees at 90°, before jumping immediately without using the arms. The jump height in cm, of the best test on five was recorded for both SJ and CMJ.

Study variables

The independent variable

It was the playing position, operationalized in this study in two modalities, i.e. the back (BC) and the front (FT) playing positions.

The dependent variables

These variables were:

- performances at the physical capacity tests i.e. the heights of SJ and CMJ, the MAS during the 30-15 IFT ($V_{30\text{-}15}$ IFT ، 30-15IFT) the running time for the single 30 m-sprint and the mean running time and the running performance decrement (FI) during RSA.
- physiological data collected in each player during the match, i.e.: the total distance covered (TDC) during the match (expressed in km), the energy expenditure (EE) during the match expressed in kcal, the maximal heart rate (HRmax) and the mean heart rate (HRm) reached during the match, the glycaemia (GLY), considered as normal for any value lower than 1.10 g/L (Grundy *et al*., 2002) the hydric status (HS) before and at the end of the match, defined with the values of the USG according to three modalities which are the state of hypo-hydration, when USG was higher than 1.020, the state of normo-hydration for all USG ranging between 1.010 and 1.020 and the state of hyper-hydration, if USG was lower than 1.010 (Casa *et al*., 2000). The thermal strain was also appreciated and the marker used was the physiological strain index (PSI) proposed by Moran *et al*. (1998) according to the formula: $PSI = 5 (T_{rect} - T_{rec0} \times (39.5 - T_{rec0}^{-1} + 5 (HR_T - HR_0 \times (180 - HR_0^{-1})$ with T_{rec0} and T_{rect}representing the rectal temperature before and after the match; HR_0 and HR_T the heart rate before and after the match. The scale of appreciation of the PSI proposed by Moran *et al*. (1998) was used to determine the level of thermal strain during the match.

The confusing variables

These variables were the body mass index (BMI), the resting heart rate (HRr), the weekly training time (WTT) and the seniority in the practice of competition handball.

Statistical analysis

The data were processed using the Statistica (Stat Soft Inc., Version 5.5) software. The normality of the distribution of the variables was checked by using the test of Kolmogorov-Smirnov. The results are presented as mean values (m) ± standard deviations (s). To compare the data before the match to those at the end of the match in each team and between front and back players, the Wilcoxon row test and the Mann Whitney U test were respectively used. The r coefficient of correlation of Bravais-Pearson between the playing average time and the distance covered was calculated and compared between BC and FT players. The level of significance of the

statistical tests and the coefficients of correlation was set at $p < 0.05$.

RESULTS

Biometric characteristics and history of handball practice

There was no significant difference ($p > 0.05$) between BC and FT players compared for age, height, body weight, BMI, WTT and seniority in the handball practice (Table 1).

Table 1. Biometric and sportive practice characteristics in studied handball players

	Entire sample (n = 17)	Front players (n = 9)	Back players (n = 8)
Age (years)	23.52 ± 0.79	23.88 ± 1.26	23.12 ± 0.97
Height (cm)	176.47 ± 0.01	174.89 ± 0.01	178.25 ± 0.06
Weight (kg)	73.88 ± 2.25	71.47 ± 2.95	75.36 ± 3.49
BMI (kg/m^2)	23.54 ± 0.57	23.37 ± 0.93	23.74 ± 0.66
WTT (hours)	9.88 ± 0.61	9.66 ± 0.61	10.12 ± 1.12
Seniority in the practice (years)	9.52 ± 0.52	9.77 ± 0.93	9.25 ± 0.37

Numbers in the cases are mean values ± standard deviations; BMI : body mass index ; *: difference significant at $p < 0.05$; **: difference significant at $p < 0.01$; RSA : repeated sprint ability ; Seniority in the practice : number of years of competition handball practice ; WTT : weekly training time.

Comparison of the results for the physical capacity tests

Mean values of $V_{30\text{-}15\text{-}IFT}$ were higher in BC ($p < 0.01$), but as Table 2 shows, that of Ta for the RSA was lower ($p < 0.01$). There was no significant difference ($p > 0.05$) between BC and FT compared for single 30 m-sprint, SJ and CMJ.

Table 2. Results of the physical capacity tests in studied handball players

	Entire sample (n = 17)	Front players (n = 9)	Back players (n = 8)
$V_{3015IFT}$ (km/h)	19.05 ± 0.31	18.38 ± 0.35	19.81 ± 0.41*
$\dot{V}O_2$ max $_{30\text{-}15IFT}$ (mL/min/kg)	57.23 ± 0.77	55.71 ± 0.93	58.95 ± 0.99*
Average time of race for the RSA test (s)	5.77 ± 0.06	5.87 ± 0.70	5.63 ± 0.06**
30 m sprint time (s)	4.21 ± 0.15	4.23 ±0.15	4.18 ± 0.15
IF (%)	6.77 ± 3.28	6.39 ± 4.27	7.19 ± 1.83
SJ (cm)	36.12 ± 4.60	35.64 ± 5.74	36.67 ± 3.32
CMJ (cm)	41.00 ± 4.49	40.90 ± 4.90	41.12 ± 4.31

Numbers in the cases are mean values ± standard deviations; $\dot{V}O_2$ max $_{30\text{-}15IFT}$: maximal oxygen uptake estimated using the results of the 30-15 IFT test (Buchheit, 2005) ; *: difference significant at $p < 0.05$; **: difference significant at $p < 0.01$; IF : fatigue index ; SJ : squat jump ; CMJ : counter movement jump ; RSA : repeated-sprint ability ; s : second

Comparisons of the resting data and those at the end of the match

Whatever the playing position (Table 3), the changes in body weight, Trec, and HR between the beginning and the end of the match were significant ($p < 0.05$), but not that of GLY ($p > 0.05$). The differences between the changes in the physiological parameters measured during the match (La, GLY, HR) in BC and those observed in the FT players were non-significant ($p > 0.05$). Before and at the end of the match, the players were all in a state of hypo-hydration (USG > 0.020), independently of the playing position.

Comparison of the match data

During the match, the FT players had an average PSI of 7.50 ± 1.98 *vs* 6.92 ± 1.53 ($p > 0.05$) in BC. There was not a significant difference between BC and FT players with regard to the time spent playing on the ground ($p > 0.05$). On the other hand, the BC covered a larger distance ($p < 0.05$) than the FT (Table 4). Whatever the play position, the coefficient of correlation (r) between the time spent playing on the court and the distance covered was non-significant ($p > 0.05$).

Table 4. Comparisons of match data by playing position among handball players

	Front players (n = 9)	Back players (n = 8)
PSI	7.50 ± 1.98	6.91 ± 1.53
Percentage of HRmax (%)	82.75 ± 3.34	82.73 ± 4.18
Distance covered (km)	3.82 ± 0.82	4.74 ± 0.81*
Average playing time (%)	67.45 ± 9.65	79.82 ± 10.92
Amount of water drunk (L)	1.22 ± 0.36	1.56 ± 0.41

Numbers in the cases are mean values ± standard deviations; PSI : physiological strain index ; average playing time: a percentage of the whole playing time ; HRmax : maximal heart rate.

DISCUSSION

The Division 1 (D1) players in the Republic of Benin chosen for this study were motivated enough to show their total engagement during the experimental match and the physical tests. Moreover, the match was played in official conditions and was directed by international referees, in order to guarantee the reliability of the data recorded. However, because of the use of a non-probabilistic sample, the results are valid only for the handball players included in the study. Anyway, the results have permitted the identification of physical capacities and physiological match data that can vary according to playing position, in West African amateur handball players. The morphological data (height and weight) collected during this study raise the problem of the passive

Table 3. Physiological data recorded by playing position at rest and at the end of the match among the studied handball players

	Front players (n = 9)			Back players (n = 8)		
	Before match	In the end	Δ1	Before match	In the end	Δ2
Weight (kg)	71.95 ± 8.83	71.16 ± 8.83**	-0.78 ± 0.47	76.05 ± 9.91	75.30 ± 9.87*	-0.68 ± 0.36
Trec (°C)	37.48 ± 0.19	38.92 ± 0.82**	1.43 ± 0.82	37.5 ± 0.35	38.76 ± 0.42*	1.26 ± 0.70
USG	1.02 ± 0.01	1.02 ± 0.00 **	0.005 ± 0.001	1.02 ± 0.00	1.03 ± 0.00*	0.006 ± 0.005
La (mmol/L)	2.77 ± 1.00	4.01 ± 1.16**	1.22 ± 1.19	3.15 ± 1.41	4.58 ± 1.56*	1.43 ± 1.10
GLY (g/L)	1.00 ± 0.14	0.94 ± 0.08	-0.05 ± 0.17	0.91 ± 0.14	0.94 ± 0.09	- 0.04 ± 0.15
HR (bpm)	71.66 ± 3.46	187.44 ± 3.24**	115.77 ± 3.23	68.12 ± 11.60	190.62 ± 7.65*	122.5 ± 13.65

Numbers in the cases are mean values ± standard deviations; USG : urine specific gravity; La : blood lactate; GLY : glycaemia or blood glucose; Trec : rectal temperature ; HR : heart rate ; *: difference significant at $p < 0.05$; **: difference significant at $p < 0.01$; Δ : difference between data recorded prior to the match and those in the end.

mode of recruitment of the handball players in the Republic of Benin. That is the absence of a detection system allowing the identification of the young players that are likely to perform well during international competitions. The studied handball players have an average VO_2max30-15IFT of 57.2 mL/min/kg, the value of which is similar to the 57.3 mL/min/kg reported for amateur handball players (Ziv and Lidor, 2009). It is however 2.6% weaker than the mean value of 58.7 ± 0.9 mL/min/kg recorded in French professionals (Rannou *et al*., 2001). The players included in this study can still improve their aerobic fitness, whenever they want to play at the top level, since at the age of 23 they still have three to five years for developing this capacity. In this cohort of handball players, back players presented on average a higher VO_2max than front players, contrary to the lower value reported in a team of adolescent players (Zapartidis *et al*., 2009). The result recorded in our study can be explained by the fact that the back players are solicited in the defensive actions to badger, push back, offset the attackers, like in the offensive actions to support the actions of the front players, and operate the defence backs and throw the ball. On the other hand, the front players are less solicited during the match, their role often being limited in defence to float at 6 m and in attack as a support for back players. The average running time during the RSA test which is better in back players than in the front ones, corroborates the results reported by Zapartidis*et al*. (2009).

The absence of difference between back and front players with regard to match La, may partly explain the similar mean values of the fatigue index in the two groups. Indeed, the physiological indexes such as HR or La permitted to estimate the intensity of the effort realized by the players' bodies and thus informed on the processes mainly involved into the energy supply during the match (Buchheit*et al.*, 2009). One should however remember that the RSA test designs do not reproduce accurately the succession of the different types of actions recorded in a match. The average height recorded at squat jump in the players of this study appears lower than the 47.5 ± 7.0 cm reported in D1 Latvian handball players (Pontaga and Zidens, 2012). The average height of the countermovement jump is lower by 16.1 cm than that reported by Pontaga and his collaborator. Moreover, there is no difference related to playing position between the performances at squat jump and counter movement jump in the players of this study. Put together, these results suggest several explanatory hypotheses. The first relates to the total training and match time accounting for handball practice which would be weak in the current study sample. Before entering the senior category, almost all the junior players have mostly one or two training sessions per week i.e. two to four hours weekly, with mostly three to four matches in a year. Even the senior players do train mostly for six to eight hours weekly, except for the international ones who usually benefit from an intensive training (14 to 24 hours per week) during the intensive preparation periods before continental or world level competitions. The second hypothesis relates to the more or less specific practice during training sessions. In Benin, taking into account the weak frequency of sessions, the trainers propose, to a large extent, exercise that is based rather on technico-tactic drills. The method used excludes any approach of individualized work, without integrating specific muscular reinforcement in the training planning. Under such conditions, it is difficult to expect obtaining performances in jump, comparable with those of high level players in whom resistance training occupies an important place in the annual training planning (Shahram *et al*., 2012). Since all the players implied in this study were dehydrated as well before as at the end of the match and that the game intensity was relatively high (82% of HRmax), the increased thermal strain recorded appears normal although players drank an average of 1.5 L of water. As it is known that the quantity of water drunk while exercising is not sufficient enough to compensate for the hydric loss, the risk of hyperthermia is always present in a hot environment (Koulman *et al*., 2003). The absence of difference between the front and back players regarding the physiological strain index could be associated with the fact that they played the match at the same % H Rmax. The players included in this study covered an average of 4.25 km during the match. This distance is higher than the 2.83 km reported in the literature (Ziv and Lidor, 2009) and twice higher than the 1.77 km recorded in adolescent handball players in Tunisia (Chelly *et al*., 2011). It is however close to the 4.79 km covered by senior professional players of the same country (Sporis *et al*., 2010). The difference observed between the back and front players in favour of the first, is most probably in relation with the tasks carried out and the requests during the match. Contrary to the data in the literature (Sibila *et al.*, 2004), the front players implied in this study covered less distance than the backs. The lower level of competition among these players would be such that the front ones play less in-depth than those of the international elite.

Limitation of the study

These results would have had more interest for the trainers and players, if match analysis had been undertaken in order to compare types of motion (slow races, back runs, sprints at maximum speed, walks, standing, jumps, and throws). It would then have been possible to know which type of motion contributed most to the difference between the distances covered by back and front players.

Conclusion

This research was carried out with the assumption that the physical capacities and match data are comparable in the Benin handball back and front players included in this study. At the end of the work, it appeared that:

1) the back players have an average of VO_2max30-15IFT, and the mean sprint race time for RSA higher than that of the front players;
2) the back players also covered a longer distance during the match.

This study provides the first analysis on the physical and physiological parameters, and match data according to playing position in the Benin elite handball players. The results suggest that the studied back players have a greater inter-effort recovery capacity during the RSA test, as well as during an isolated match, as indicated by the average race time and distance covered. Further research must confirm this tendency with a series of three-consecutive match design, such as it is often scheduled during handball continental competitions.

These data also draw the attention of the Division 1 team trainers of Benin on the lower limb muscular weakness of the players whatever the playing position. It is thus obvious that there is not enough muscular reinforcement for the players' strengthening, in the training planning of the teams in this country and that from now, it must be an integral part of the training schedule.

Acknowledgement

The authors thank the handball players who took part in the study, as well as the trainers and the authorities of the Division 1 teams who agreed to release the players for match and assessment sessions. We are also grateful to the people in charge of the *VITA FORM* Fitness Centre of Porto-Novo, for their technical support during data collection and processing.

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