Application of Bioelectrical Vector Analysis in Professional Soccer Players

BIVA in Sport

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Abstract: Soccer is a sport team with a discontinuous nature of physical effort and the duration of the regular season is 10 months length. Hydration status, water consumption are aspects of human performance debate in recent years and it's well demonstrated as a reduction of total body water impairs endurance ability. Bio impedance is a useful methods to assess total body water, in addition recent studies reports a new approach in the evaluation of hydration status independently from body weight. The aim of the study was to determine changes of the bioelectrical impedance throughout a soccer season. Bioelectrical parameters of a Italian professional football team were recorded eight time during a regular season. The detection were carried out following the standard tetra polar method. Twenty-five male soccer players were submitted at BIA measurement, but only eleven athletes took part in all eight sessions detection. The data recorded by conventional BIA processing didn't show any statistical differences in weight, hydration and cellular masses. Bio Impedance Vector Analysis (BIVA) shows a high significance in Anova test for the values of Xc ($p<0.01$) and PA ($p<0.001$), no difference in Rz among eight measurements. Body composition and hydration status in footballers are generally well and the variations in conventional BIA are minimal. Therefore BIVA in this population may give specific information for physiological changes for training dues. A regular bio impedance assessment in athletes is desirable to follow adaptations to training loads.

1 INTRODUCTION

Many sports such as football, rugby and basketball have a discontinuous nature of physical effort, consisting in prolonged periods of exercise with repeated intermittent high intensity bursts interspersed with lower-intensity exercise: football is a sport team and his sudden changes in intensity is due to its intrinsic nature dictated by tactical and technical reasons (Di Salvo V, 2008).

A regular season in professional Italian soccer league during 10 months and the level of exercise could induces muscle-tendon injuries, overuse syndromes, over-reaching and even over-training syndromes causing days of absence from the sport (Bahr R., 2009; Kellmann M., 2010).

During matches and training, soccer players are exposed to high physical stress (Bangsbo J, 2006), which is suggested to influence body composition and hydration status.

Hydration status, water consumption and the effects of hypo hydration on aspects of human performance, health and wellbeing have been the topic of much public and scientific debate in recent years. The effect of body water balance on aspects of exercise performance has been extensively researched and in recent years has been reviewed widely (Cheuvront SN, 2003; Coyle EF, 2004; Judelson DA, 2007). Correct rehydration is sufficient to limit body mass loss to 1.4%, prevents a reduction in soccer skill performance (McGregor S, 1999) in comparison with performance when body mass is reduced by 2.5%. Body water loss in human subjects results in fluid losses from both the intracellular and extracellular fluid compartments (Costill DL, 1976). More recently, the influence of hydration status on the movement patterns in football has been investigated (Edwards AM,, 2007) using the 'yo-yo' intermittent recovery test (Krustrup P, 2003; Bangsbo J, 2008): a reduction of 2.1% or 2.4% in

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body mass induced a reductions of 13% and 15% respectively in ‘yo-yo’ test performance.

Bioelectrical impedance analysis (BIA) is a property-based method of body composition specifically detecting soft tissue hydration with a 2–3% measurement error, which is comparable to routine laboratory tests (Piccoli A, 2002).

Applications in sport have been primarily for body composition analysis (Yannakoulia M, 2000), and recently for assessment of nutritional status and soft tissue composition in soccer players (Gatterer H, 2011).

The aims of this study was collect bioelectrical parameters in soccer players in order to check the hydration status during an entire season.

2 METHODS

Twenty-five male soccer players were submitted to BIA measurement during all regular season, but only eleven athletes (age 22.4±1.8 years, height 181.3±7.7 m) took part in all eight sessions detection. Absence were due to health reason (including injuries), soccer players arrived during the season and the goalkeepers are not included in this study.

Design: Observational longitudinal prospective study.

A professional football team taking part at Italian fourth soccer division begins the season in July.
After having received oral consent to carry out the evaluations, at the first training session (T1) were performs anthropometrics and bioelectrical analysis.

Bioimpedance parameters for each players were recorded in the morning, at rest condition, without physical activity in the previous 12 h and following the standard tetrapolar method (BIA 101 Sport Edition, Akern, Florence, Italy). To detect any difference in bioelectrical and hydration values of lean body mass during the season bio impedance analysis were done three weeks after the first evaluation (T2) and then every forty days always in Wednesday morning: total assessment were eight in all season (T3-T8).

Body impedance is generated in soft tissues as an opposition to the flow of an injected alternate current and is measured from skin electrodes that are placed on hand and foot (whole body analysis). The resistance (Rz) is the opposition to the flow of an injected alternating current, at any current frequency, through intra and extracellular ionic solutions, while reactance (Xc) is the dielectric or capacitative component of cell membranes and organelles, and tissue interfaces.

Data analysis were perform by software Bodygram PRO 3.0 and detect with a convectional analysis (BIA) and Vector analysis (BIVA).

Conventional BIA is based on electric models supporting quantitative estimates of body compartments through regression equations which are not valid in individuals with altered hydration.
Bioelectrical impedance vector analysis (BIVA) is based on patterns of the resistance-reactance graph (Rz - Xc graph) relating body impedance to body hydration without equations (Kyle UG, 2004). A simple algorithm with few operational rules has been derived for interpreting impedance vector position and migration on the Rz - Xc graph at the bedside in any clinical condition. Impedance (Z vector, ohm) is represented with a point in the Rz - Xc plane which is a combination of Rz and Xc. Vector normalization by the subject’s height (Z/H, in Ω/m) controls for the different conductor length (Codognotto M, 2008). This new methods is mainly used in clinical conditions, few studies are now present in literature (Jaffrin MY, 2009).

Data from conventional analysis were:
free fat mass (FFM), fat mass (FM), total water (TBW), extracellular water (ECW), intracellular water (ICW), body cellular mass (BCM), extra cellular mass (ECM).

For vector analysis the bioelectrical parameters resistance, reactance and phase angle (PA) lead to the development of resistance-reactance graph.

For each parameter recorded in the eight sessions was performed statistical analysis with ANOVA Test.

3 RESULTS

The data recorded by conventional BIA processing were report in table 1and didn’t show any statistical differences both in weight, hydration and cellular masses.

Bio Impedance Vector Analysis shows a high significance in Anova test for the values of Xc and PA (table 2), but no difference in Rz among the eight measurements.

Figures 1 shown the vector analysis of the eight assessment during the regular season: sample group it is positioned for whole regular season in athlete’s area characterized by a state of lower general hydration and a higher cellular mass respect the general population.

The position of sample group in vector graph, however, varies from July to May and it is possible

Table 1: Conventional BIA results.

	Weight (kg)	FFM (kg)	FM (kg)	TBW (L)	ECW (L)	ICW (L)	BCM (kg)	ECM (kg)
T1	74.9±6.4	62.2±5.9	12.7±2.4	45.5±4.3	18.0±2.0	27.5±3.0	37.6±3.5	24.5±2.9
T2	75.6±6.7	63.5±6.2	12.0±2.1	46.5±4.5	18.6±1.9	27.9±3.1	38.1±3.8	25.3±2.6
T3	75.0±6.6	63.0±6.1	12.0±2.1	46.1±4.5	18.5±2.0	27.6±31	37.7±3.7	25.2±2.8
T4	75.3±6.5	62.2±6.5	13.0±2.5	45.5±4.7	17.4±2.4	28.1±2.9	38.6±4.0	23.5±3.5
T5	76.4±6.5	62.1±6.1	14.2±2.2	45.5±4.4	17.6±2.2	27.9±3.0	38.3±3.5	23.8±3.1
T6	76.3±6.5	62.8±6.4	13.5±2.2	45.9±4.7	17.2±2.2	28.7±3.0	39.5±4.1	23.2±3.1
T7	76.1±6.2	62.1±5.9	13.9±2.0	45.5±4.3	17.4±2.2	28.0±2.8	38.5±3.6	23.6±3.2
T8	75.9±6.7	63.8±6.5	12.2±2.1	46.7±4.7	17.7±2.1	28.9±3.1	39.8±4.2	23.9±3.1
Anova	NS	NS	NS	NS	NS	NS	NS	NS

Legend: FFM = Free Fat Mass, FM = Fat Mass, TBW = Total Body Water, ECW = Extra Cellular Water, ICW = Intra Cellular Water.

Table 2 BIVA results.

	Rz (ohm)	Xc (ohm)	PA (°)
T1	496.4±37.9	65.8±7.4	7.5±0.5
T2	481.1±36.6	62.5±5.0	7.4±0.3
T3	485.5±32.6	62.9±5.1	7.3±0.3
T4	498.0±44.3	70.0±10.3	8.0±0.8
T5	502.2±37.4	69.1±7.5	7.8±0.5
T6	494.0±42.2	71.3±9.0	8.2±0.7
T7	501.1±40.9	70.1±8.5	7.9±0.8
T8	479.9±38.5	68.0±7.9	8.0±0.6
Anova	NS	<0.01	<0.001

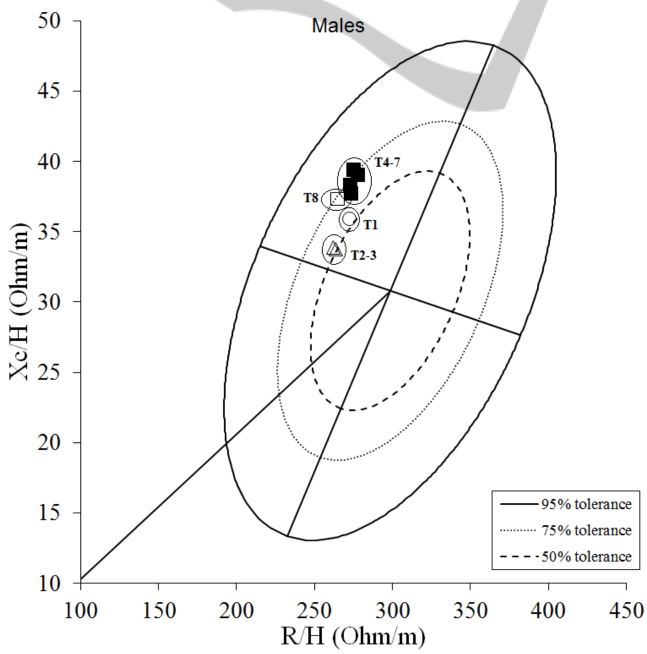

Figure 1: Bia Vector with res.istance-reactance graph of soccer players.

to identify four major groups T1, T2-T3, T4-T7, T8. From the first detection (T1) is present in an initial rehydration phase (T2-T3).

In T3-T7 vector analysis shows a loss of fluids with slight increase in cell mass. Last assessment T8 shows an overall increase in body water.

4 DISCUSSION

The usefulness of body impedance measurement in sports derives from an immediate availability as a noninvasive, inexpensive and transportable test that transforms electrical properties of tissues into body composition information (Kyle UG, 2004).

Acute changes in body mass over a short time period can frequently be assumed to be a result of body water loss or gain (Lentner C, 1981; Maughan RJ, 2007) and therefore changes in body mass can be used to quantify water gain or loss.

A regular season in professional soccer is 10 months length, during this time the footballers has in average 250 training session and 45 official matches: during this time numerous physiological changes occurs. Footballers are in young age and the parameters of body composition and hydration are generally regular, therefore small variations in conventional analysis (BIA) were reported.

Bio Impedance Vector Analysis (BIVA) in this particular sports population may give specific information for physiological changes for training dues.

In July, at the first analysis (T1), players has a good condition but a lower level of training, there were considered the baseline of bioelectrical values.

In August (T2) and in September (T3) the temperature and the training load were high: Rz, Xc and PA reached the minimum values with statistical differences for Xc and PA, we can assume a redistribution of body water as a first response to training loads.

Vector parameters from T4 to T7 are stabilized and do not differ among themselves, during this phase physical effort of athletes can be considered stable.

In last evaluation (T8) the increase in body water can be attributed to a decrease in training load by the end of the official games.

In conclusion the shift of sample group within the Rz - Xc graph during the eight assessments shows how the body of athletes, through training, initially (T2-T3) undergoes an increase and redistribution of body water (in favor of the extra-cellular compartment), then the cellular mass (lean body mass) increase simultaneously with a reduction in body water (T4-T8).

A regular Bio Impedance Analysis for physiological assessment in athletes is advisable to follow the adaptations to training loads. In particular during the initial period of regular season when the high level of physical effort is required: during this period water loss through the sweat will be prevented and replenished during and after the single training sessions.

Also to be considered both the increase in the summer period and the not change during the season in total body water in order to plan the training. Therefore medical and technical staff will have information to avoid a possible occurrence of overreaching or overtraining syndrome.

5 CONCLUSIONS

Conventional BIA analysis does not appear sensitivity to detect athletes adaptations: bioelectrical values as Resistance, Reactance, Phase Angle and therefore a Bio Impedance Vector Analysis (BIVA) is proved more sensitive to physiological adaptation in sports subjects.

Future research is needed to determine which are the most stressed muscle groups of the lower limb from training in football

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