

**Translated from**

**ADAPTIVE PHYSICAL CULTURE 2016, № 2 (66) :2-5.**

**Prediction of the competitive readiness of Paralympic athletes on the basis of assessment of the circadian rhythm by Gas Discharge Visualization method**

Banajan A A<sup>1,2</sup>, Grachev A A<sup>1</sup>, Korotkov K G<sup>1</sup>, Korotkova A K<sup>1</sup>

1 Petersburg Research Institute of Physical Culture and Sport of the Russian Ministry of Sport, Saint Petersburg, Russia.

2 Federal Research and Clinical Center of Sport Medicine and Rehabilitation of the Federal Medical and Biological Agency, Moscow, Russia.

Keywords: Paralympic sport, psychophysiological state, the energy state of a person, gas discharge visualization, GDV, Bio-Well, rapid assessment, competition.

**Abstract**

The possibility of applying the method of gas discharge visualization (GDV) for the rapid assessment of psycho-physiological readiness of athletes for the upcoming competition was investigated based on the results of the Russian national sledge hockey team at international tournaments. Significant correlations between GDV parameters of athletes and efficiency of their performances in competition was found.

**Introduction**

The development of methods allowing to predict the performances of athletes at the competition is the most important and ambitious task in sports. The presence of such an effective method could help coaches to make the right choice of players for the upcoming tournament and could significantly improve the team performance at the competitions.

People and in particular athletes are the most complex energy and information systems whose state depends on a number of factors. Quite often even professional athletes happen to perform poor, and if this athlete is a member of the team, this may lead to bad performance of the whole team. The reason for the poor performance of a player is determined by his/her poor physiological condition, which may affect such seemingly not related to the professional activity factors as turmoil in his personal or family life, emotional exhaustion from other kinds of activity, poor diet, overtraining in the preparatory phase to the competition, etc.

Gas-discharge visualization method (GDV) for the diagnosis of the human condition, actively developed in recent years in the world and especially in Russia to determine the psycho-physiological state of athletes takes into account the influence of many negative factors to the psychophysiological state of an athlete. These peculiarities of the GDV technique makes it an invaluable diagnostic tool in sports. Other advantages of the GDV technique include ease of use, noninvasive and very short time for analysis, which is very important in the case of sport applications, since athletes often emotionally overwhelmed at the competition and do not have

enough time and energy for long and complex laboratory studies, which can further overload their emotional state.

This article is a continuation of a series of papers [1-3] on the application of the Gas Discharge Visualization (GDV) technique for determining the psycho-physiological state of athletes. In previous papers we discussed the use of GDV to determine the effect of sports training on athletes. This article examines the possibility of evaluation of competition efficiency of individual athletes based on GDV method data.

### **Methods**

GDV method allows rapid assessment of the energy potential (EP) and the level of stress (SL), which together characterize the psycho-physiological state of athletes [1-3]. Parameter EP is ranging from 0 to 100 Joules and characterizes the energy level correlated with psychophysiological state of an athlete. High EP values indicate a high level of energy reserve and a high degree of psycho-physiological readiness of the athlete. The parameter SL reflects the level of physiological stress and is measured in relative units from 0 to 10, where 10 units correspond to the maximum level of stress.

GDV "Bio-Well" device designed for the diagnosis of mental and physical capacity and quality of health ([www.bio-well.com](http://www.bio-well.com)) was used in the research. The measurements were performed on a daily basis, readings taken from two ring fingers of both hands, in the morning immediately after getting up and in the evening after the end of training. This method of measurement takes less than one minute on the readings of one athlete and allows to determine the energy potential (EP) and the level of stress (SL). On the basis of these two indicators an integral energy parameter (IEP) of psychophysiological readiness of athletes in according to the following formula was calculated:

$$\text{IEP (Joules)} = \text{EP} - k \cdot \text{SL},$$

where  $k = 10$  Joules.

IEP values less than 0 indicate a low level of psycho-physiological readiness of an athlete, from 0 to 20 J - the average level of psycho-physiological readiness, and more than 20 J - a high level of psycho-physiological readiness. It was shown [4] that the value of IEP, measured in athletes in the training camp before the competition reflect adequately their psychophysiological state and the response of their organisms to exercise.

The study involved athletes of the Paralympic team of Russia on sledge-hockey with deprived conditions of the musculoskeletal system (lower limb amputation), men aged 17 to 40 years. The study was conducted at six training events.

This research was devoted to investigation of the possibility of predicting the results of the sportsmen of the sledge-hockey team at the international competitions on the basis of the IEP parameter measured in the morning (just after sleep) in the days of the competition.

The "competition efficiency" was calculated based on the outcome of sports players' performance [5]. Five sport characteristics were considered as the indicators - effectiveness of transfers (%), effectiveness of faceoffs (%), effectiveness of throws (%), efficiency of strokes (%), effectiveness of fighting (%). To calculate the efficiency of each player the average value for all five indicators was calculated.

We analyzed results of performances of sportsmen of Russian national team in two international tournaments - in Podolsk (Russia) 13 – 16 January 2014, in which the team played three matches with the teams of Sweden, Norway and the Czech Republic; and in Turin (Italy) 03 – 09 November 2014, in which the team played four games with the teams of Norway and Italy. Note that the Russian team won all the matches, and the vast majority by a significant margin.

## Results

IEP indexes were compared with the values of the parameter "Efficiency" (figure 1), calculated based on the players performance. The results of goalkeepers were not considered, as their play has a very specific character, which is difficult to compare with defenders and attackers.

Visual analysis of IEP and "Efficiency" indexes values for all players based on the results of match between teams of Russia and Norway in the Torino tournament (figure 1) allows to suggest that between these indexes may exist correlation, since the variations of charts for the most part happens simbitically.

Figure 1. A chart showing the IEP and "Performance" indexes for athletes of the Russian sledge hockey team at the Norway-Russia match in Turin in November 2014.

To confirm the correlation between values IEP and efficiency of performance we used the methods of correlation analysis, namely the calculation of the rank Spearman correlation coefficient. This coefficient determines the degree of tightness of the connection sequence of signs, which in this case represent the grades of the compared values. The conditions of applicability of the coefficient [6] correspond to the analyzed conditions. Rank Spearman correlation coefficient is calculated by the formula [6]:

$$RAM = 1 - \frac{6 \sum (D^2)}{n(n^2 - 1)}$$

where n - the number of ranked signs (metrics, test);

D - the difference between the ranks in two variables for each participant;

$\sum (D^2)$  - the sum of squares of rank differences.

The Spearman coefficient, calculated on the results of the Norway-Russia match in Torino on the basis of 12 players (all except the goalie), is equal  $RAM = 0.41$ . For the 12 ranked values the critical values of the rank correlation coefficient is 0.58 for the significance level  $p < 0.05$  [4]. Thus, the coefficient RAM has a value that is less than the critical ratio. However, a similar calculation carried out without taking into account one player (No.11 fig.1) gives the Spearman coefficient  $RAM = 0.68$  (table 1), and the critical value of the coefficient for 11 players is 0.61 for the significance level of  $p < 0.05$  [4]. The resulting value of the rank correlation coefficient RAM, calculated for 11 players (excluding one player), converts the result into a region of statistically significant correlations between IEP index of athletes and "Efficiency" of their performances in this match.

In the case of the other three matches played by a Russian team in Turin, we also observed significant correlations between the IEP index and "Efficiency" when excluding from consideration two to three players (table 1).

In the case of the team's performance in Podolsk in the match Russia - Norway, the Spearman coefficient for 14 people (excluding one player at number 10, figure 2)  $R_{AM} = 0.77$  that greatly exceeds the critical value of the coefficient equal 0.54 for the significance level  $p < 0.05$  (table 1). This shows that there is significant positive correlation between these values. In the case of Russia - Sweden match in Podolsk a significant positive correlation between the IEP index and "Efficiency" was also observed (excluding 2 players, table 1). However, in the case of Russia - Czech Republic game we failed to obtain reliable correlations between quantities IEP and "Efficiency".

We pay attention that the overall level of IEP index in Podolsk was lower than in Turin (averaged on the team values of IEP in Podolsk is 26.35 and 36.52 in Turin). This may be related to the fact that Podolsk games were held in January – in the middle of the sport hockey season, when athletes were tired after a long winter season, while Turin games were in September, after the long relaxing session in the summer training camp.

Figure 2. A chart showing the IEP and "Performance" indexes for athletes of the Russian sledge hockey players at the Norway-Russia match in Podolsk in January 2014.

## Discussion

As can be seen from Table 1, from 7 games good correlation between the integral energy parameter IEP and performance of players was observed in 6 cases. Results were obtained by excluding from consideration from one to three players. This allows to speak about existence of a positive relationship between psycho-physiological state of an athlete and his competitive success. At the same time, for some athletes on certain days this trend was violated, which may be related to rhythmic variations of the condition, or the influence of some external causes (meals on the previous day, sleep quality, emotional state, adjustment to the game, etc.). Note that different athletes were excluded from consideration, indicating that the correlations were influenced by momentary factors on a specific day. We need to emphasize that the analyzed team is highly professional, one of the leading in the world in its category, and the athletes belong to the elite of Paralympic sport.

Further research will show whether these correlations are valid for athletes of different levels of training in various sports disciplines. At the same time, the results, together with previously published data [1-3], show that the developed technique gives the coach a convenient, easy to use, fast additional tool for assessing and monitoring the psychophysiological state of athletes.

Obviously, the high values of the energy potential and the low values of the coefficient of stress in the morning testifies to the full recovery of athletes during sleep and low levels of stress and anxiety, which is the key to the success in competitive activity. It is known that stress has a negative impact on the efficiency of performance of athletes and prevents them to fully use the existing potential [7].

It should be noted that the relative efficiency of each individual player of a team couldn't depend on the psychophysiological state of players from the opposing team. At the same time, the efficiency of the whole team (not individual players) is dependent on the level of opposing team. However, the higher the average IEP index for the whole team, the more chances to win, as evidenced by the results of Russian sledge hockey team performance in tournaments in Turin and Podolsk. High IEP values equal to 36.5 (Turin) and 26.3 (Podolsk), obtained by averaging across the team of the Russian Federation for all the days of competition, correspond to high results at both tournaments, where the Russian sledge hockey team won all matches.

### **Conclusion**

Presented results and significant correlations between GDV parameters of athletes and efficiency of their performances in competition found demonstrate the possibility of applying the method of gas discharge visualization (GDV) for the rapid assessment of psycho-physiological readiness of athletes for the upcoming competition at international tournaments. Further investigation is needed to find the scope and limits of the developed approach.

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**Table 1.** The results of correlation analysis for the matches in Torino and in Podolsk.

Play	Final Score	Amount of players	Amount of players excluded from calculation	Calculated Spearman coefficient	Critical Spearman coefficient for $p < 0.05$
Norway - Russia , Turin	0:06	12	1	0.68	0.61
Norway - Russia , Turin	0:01	13	2	0.63	0.61
Italy – Russia, Turin	1:03	13	3	0.66	0.64
Italy – Russia, Turin	1:04	11	3	0.76	0.72
Norway - Russia , Podolsk	0:07	14	1	0.76	0.54
Sweden – Russia, Podolsk	1:08	15	2	0.61	0.56
Czech – Russia, Podolsk	0:06	15	-	0.16	0.56

Отформатировано: Английский (США)

### **Figure Legends**

Figure 1. A chart showing the IEP and “Performance” indexes for athletes of the Russian sledge hockey team at the Norway–Russia match in Turin in November 2014.

Figure 2. A chart showing the IEP and “Performance” indexes for athletes of the Russian sledge hockey players at the Norway–Russia match in Podolsk in January 2014.

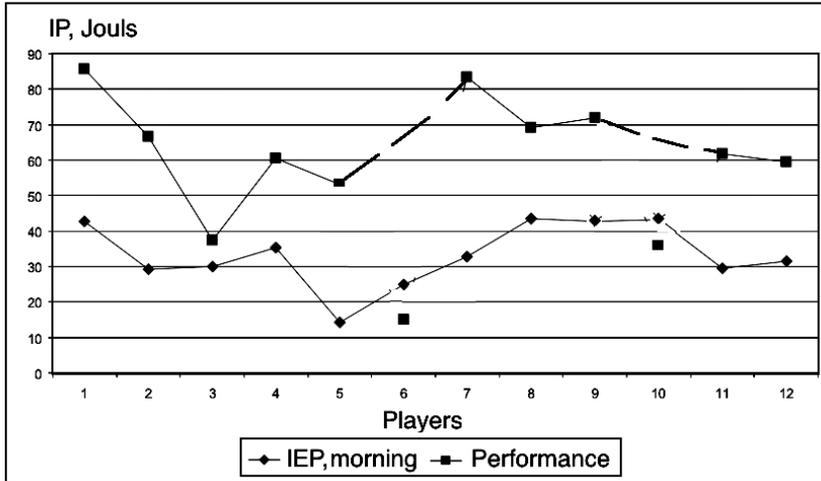


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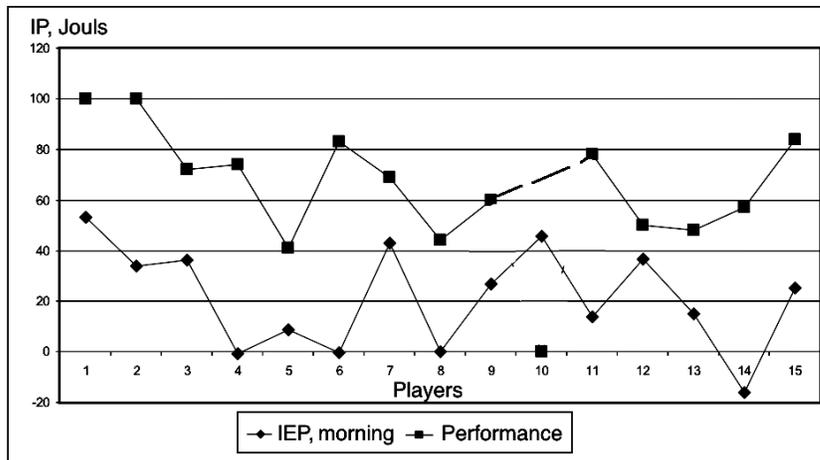


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