# Autonomic Arousal–An Early Indicator for the Development of Sleep Breathing Disturbances in Athletes

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**Abstract:** ***Background**: Sleep is essential for everyone and is important for normal human functioning. Lack of sleep, called sleep deprivation, is a condition leading to poor sport training and achievements. Different factors contribute to sleep deprivation in athletes. Respiratory sleep disorders as Upper Airway Resistance Syndrome (UARS) and Obstructive Sleep Apnea (OSA) are factors that rebound most to sleep deprivation for certain groups of athletes such as wrestlers, judists and sumo wrestlers especially. **Objective**: The present study investigates the UARS and OSA occurrence in the above mentioned groups of athletes using Pulse Transit Time (PTT) as an early noninvasive indicator of respiratory effort and sympathetic nervous system activity. **Methods**: The study involved ten elite athletes from wrestling, judo and sumo wrestling. The participants underwent full standard polysomnographic examination using Alice 5 System Philips - Respironics Inc. with the registration of PTT. **Results**: At all athletes, regardless of the presence of changes in hemoglobin saturation or Apnoea-Hypopnea Index (AHI) changes was observed significant drop in the value of PTT more than 8-15 ms for stage N1 and N2 (p<0,005), as well as more than 6-8 ms for stage N3 (p<0,005). We found bigger dependence of PTT by Arousal Index (ArI) than AHI and Dessaturation Index (DI) Therefore, PTT can be used as a good indicator for sleep fragmentation before the development of the clinical picture of OSA and UARS. **Conclusion**: As a good indicator for inspiratory effort and sympathetic changes in UARS and OSA, PTT gives an opportunity for early diagnosis of respiratory sleep disorders among athletes. Prevention, timely detection and appropriate treatment of sleep disorders before the development of their full clinical picture will improve the processes of recovery and performance in sport practice.*

**Keywords:** Sleep; Athletes;Pulse Transit Time

## 1. Introduction

Sleep deprivation is a condition which results in a lack of sleep caused by various factors. Its chronic form leads to excessive daytime sleepiness and it is a high stress factor for individuals. Sleep deprivation leads to cognitive deficits, deterioration of memory capacity, lowered immunity, heart and cerebral problems, muscle tremors, increased reaction time, etc. This affects performance and alertness among all of us. In regard to sport, sleep is one of the most important forms of recovery and its absence has negative effects on the athlete's organism and his sport achievements.

Acute sleep deprivation leads to the obvious harmful physiological effects and altered mental status of the athlete [1]. Various tests with loads, performed after sleep deprivation, showed decrease of fatigue onset time [2], [3], change in morning levels of different hormones important for athletes [4] and abnormal metabolism, which hampers the delivery and storage of energy substrates to muscles so important for endurance [5].
The assessment of sleep deprivation is subjective and objective. Our goal is always to objectify the problem. In recent years the newest equipment for sleep investigation advanced vigorously, owing the introduction of more accurate methods and criteria for the objective study of sleep deficit.

Arousals during sleep are closely related to the pathophysiology of sleep disorders. The term "arousal" means a temporary condition of awakening during sleep [6]. According to American Association of Sleep Medicine (AASM) (1992) cortical arousals are pathological phenomenon (3-15 seconds), transient signs of wakefulness during sleep, violating the proper functioning of sleep cycles and fragmenting their structure.

Usually autonomic arousal chronologically precedes cortical. It consists of wakefulness in "subcortical" level, including the autonomic nervous system. An important indicator of this is the time in which the pulse wave travels from the aortic valve to the periphery (plethysmographic sensor of the finger). This is a relatively new indicator - Pulse Transit Time (PTT). The speed with which this wave travels is proportional to rigidity of the arterial wall. An acute rise in sympathetic activity which follows an airflow cessation constricts blood vessels, hence, the arterial wall becomes stiffer causing the PTT to shorten. Thus also interrupts sleep and the result is increased daytime sleepiness. Moreover, it appears that autonomic arousal can be used as an early indicator of respiratory disorders and cardiovascular risk in patients with mild forms of the Obstructive Sleep Apnea (OSA), particularly those with Upper Airway Resistance Syndrome (UARS) [7], [8].

The study was designed to investigate the prevalence of UARS and mild OSA between athletes from certain sports using autonomic arousal and therefore to assess consequences for sport performance and recovery.

## 2. Methods

High-performance athletes (wrestlers, sumo and judo wrestlers) aged 25 ± 5 y. from the National Sports Academy, Sofia, Bulgaria were recruited for participation in the study. Both informed consent and institutional local research ethical approval were obtained for the present study.

All subjects (67 elite athletes - 27 wrestlers – 23 yrs ± 3; 15 sumo wrestlers – 23 yrs ± 6; 10 judo athletes - 18 yrs ± 4) were screened by enquiry for sleep-disordered breathing (daytime sleepiness, disturbed sleep, daytime fatigue and loud snoring). An electronic screening device – portable pulse oximetry instrument (OXY-100) was applied after the inquiry. The most suspicious cases (n=10) for sleep breathing disturbances underwent full standard overnight polysomnography (PSG) by means of Alice 5 *Philips - Respironics Inc*. equipment.

The polysomnographic recordings consisted of electroencephalogram, electrooculogram, electromyogram, electrocardiogram (ECG), chest wall movement, nasal and oral airflow and oxygen saturation. The following parameters were estimated: PTT – recording of the time interval between the ECG R-wave and the 50% of the height of the maximum value of photoplethysmographic pulse wave form, normal velocity is 250-280 ms (fig.1);

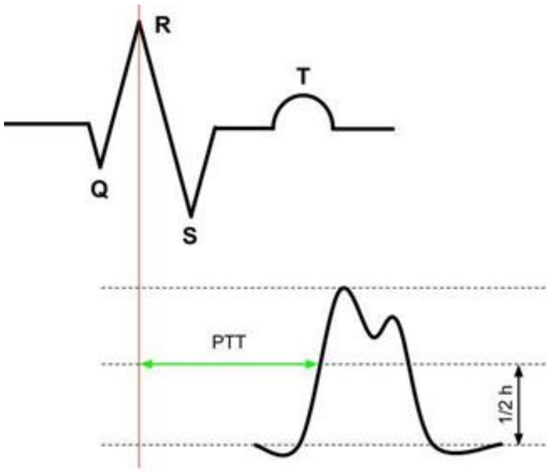


**Figure 1:** Measurement of PTT

Apnea/Hypopnea Index (AHI) – number of apneas (cessation of both nasal and oral airflow for a minimum of 10 seconds), and hypopneas (a reduction in airflow to 50% of baseline in association with oxygen desaturation) per hour of sleep; Desaturation Index (DI) – number of decrement in oxygen saturation below 4% for a minimum 10 sec. per a sleep hour; Arousal Index (ArI) – number of desynchronisations in EEG for at least 3 sec. after the previous 10 sec. sleep stage. Indexes AHI, DI and ArI ≤5 are considered normal.

## 3. Results

During sleep a normal fluctuation in the value of PTT is observed. The following levels of PTT, according to the relevant stages of sleep, are considered as normal: PTT shortening with up to 15 ms for sleep stages N1 and N2 and with up to 8 ms for stage N3.

The first figure demonstrates the PTT drop compared to norm. We found significant PTT shortening with more than 15 ms for sleep stages N1 and N2 and with more than 8 ms for stage N3 (Fig. 2). In all of the 10 athletes PTT shortening is observed, regardless of the presence of dessaturation or AHI. This proves the presence of respiratory sleep disturbance in early stage.

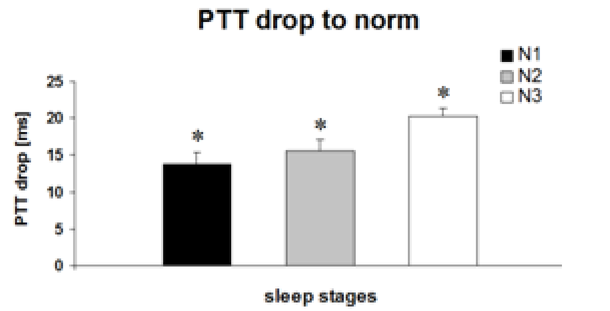


**Figure 2:** PTT shortening for sleep stages N1, N2 and N3 (n=10)

We compared PTT shortening in correlation with AHI, ArI and DI. Pearson correlation analysis showed the following:

**Table 1:** Pearson correlation analysis PTT/AHI, ArI and DI

| | | PTT | AHI | ARI | DI |
|---|---|---|---|---|---|
| PTT | Pearson Correlation | 1 | .675* | .922** | .728* |
| | Sig. (2-tailed) | | 0.032 | 0 | 0.017 |
| | N | 10 | 10 | 10 | 10 |
| AHI | Pearson Correlation | .675* | 1 | .798** | .781** |
| | Sig. (2-tailed) | 0.032 | | 0.006 | 0.008 |
| | N | 10 | 10 | 10 | 10 |
| ARI | Pearson Correlation | .922** | .798** | 1 | .847** |
| | Sig. (2-tailed) | 0 | 0.006 | | 0.002 |
| | N | 10 | 10 | 10 | 10 |
| DI | Pearson Correlation | .728* | .781** | .847** | 1 |
| | Sig. (2-tailed) | 0.017 | 0.008 | 0.002 | |
| | N | 10 | 10 | 10 | 10 |

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

The Pearson correlation demonstrated greater dependence of PTT shortening of ArI than AHI and DI (table 1).

Correlation between PTT and ArI is very significant (p=0.0001) (Fig. 3a). The correlations PTT/AHI (p=0.032) (Fig. 3b) and PTT/DI (p=0.017) (Fig. 3c) are also great, but not with as much significance.

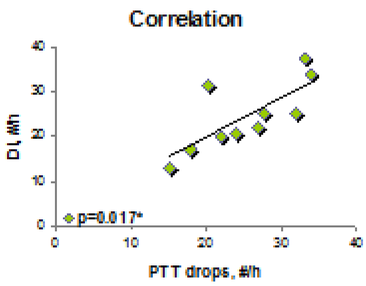


**Figure 3 (a):** PTT drops/ArI correlation

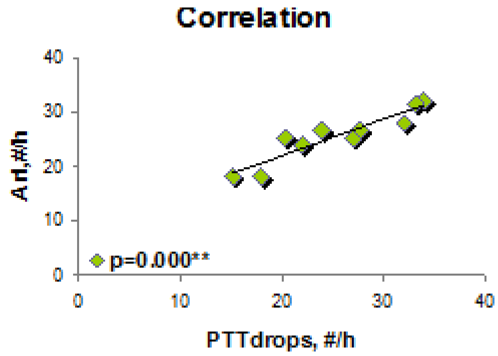


**Figure 3 (b):** PTT drops/AHI correlation

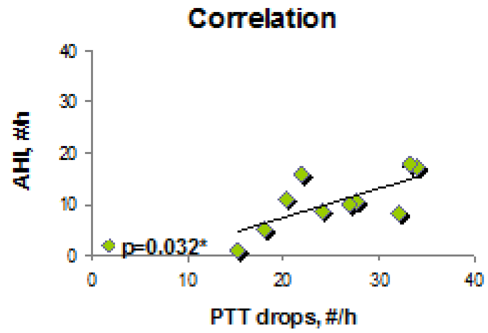


**Figure 3 (c):** PTT drops/DI correlation

Dependence of PTT by ArI means that PTT can be used as a good indicator of sleep fragmentation (ArI is an indicator of disturbed sleep) before the deployment of the clinical picture of apnoeic pauses (AHI and DI). PTT is as good as EEG micro-arousals at predicting subjective sleepiness. So PTT detects subcortical/autonomic arousals.

## 4. Discussion

Elite athletes are not spared from the problem of sleep deprivation. In some sports, especially sumo, heavy athletics, etc. percentage of suffering from sleep disorders is higher than that of non-sports people [9]. Various tests with loads performed after sleep deprivation showed decrease time to onset of fatigue [2], [3], and the period of sensitive perceptions is extended. Remes K., et al. (1985) investigate plasma levels of certain androgens important for athletes after 21 km march with 11 well-trained and 11 poorly trained military newcomers after sleep-deprivation. Morning levels of testosterone, luteinizing hormone and androstenedione are significantly diminished after sleep-deprived stress [4]. Souissi N. et al. (2007) monitored anaerobic reduction of force after 36 hours of sleep deprivation [10].

Slow-wave sleep is critical for athletes because it covers part of the cycle in which growth hormone is secreted by the pituitary gland. Growth hormone not only has an anabolic effect, but also stimulates fat burning and normalization of muscle biochemistry and therefore it is considered as one of the key hormones of the recovery.

Chronic lack of sleep, especially in heavy training regime before competition, leads to serious negative consequences. An active sports person needs a longer sleep than the usual 6-9 hours per day for non-sports.

In young athletes sleep breathing disorders are characterized by discrete changes. The standard screening methods for these sleep disturbances detect airflow change (AHI) or saturation changes (DI). Based on correlation analysis, however, we found that changes in these parameters are at later stage of disease development and are unreliable in early observation of sleep deprivation.

## 5. Conclusion

PTT proves reliable, easy to use and inexpensive method for screening of sleep breathing disorders. Therefore we strongly recommend its wide use in monitoring sleep of the athletes.

In conclusion - prevention and early detection of sleep deprivation using relatively simple methods undoubtedly would help answer many questions related to poor recovery in sport. Adequate treatment of the problem of sleep deprivation would not only improve performance but also the quality of life for athletes having these problems.

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