BRIEF REPORTS

# Monitoring the Internal Training Load and Surrogate Measures in a Senior Female Paralympic Athlete with Spinal Cord Injury: A Case Study

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## *ABSTRACT*

***Purpose:*** *Paralympic Games were started originally for therapeutic reasons; nowadays they demonstrate the characteristics of high-performance sports. The surrogate measures (e.g., sleeping habits) and the internal training load (ITL) measures are strongly associated and are used to monitor performance in sport. This study aimed to understand whether the relationship between internal training load and surrogate measures, observed over a 16-week period, would be beneficial or otherwise in the case of a senior female Paralympic athlete with spinal cord injury, who was training to compete in table tennis at the Parapan American Games in Lima.*

***Method:*** *This case study evaluated the surrogate measures through the Heart Rate Variability measure, the Wisconsin Upper Respiratory Symptom Survey and the Pittsburgh Sleep Quality Index and assessed their relationship with the internal training load.*

***Results:*** *The data demonstrated that during the monitoring period the athlete presented minimal fluctuations in the Heart Rate Variability measure, the Wisconsin Upper Respiratory Symptom Survey and the Pittsburgh Sleep Index. Significance was considered at p< 0.05.*

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***Conclusion and Implication***: *Contrary to the athlete`s age and physical condition, the data demonstrated some gains towards her success in the sporting competition. A new approach in monitoring internal training load associated with surrogate measures is necessary. It could prove to be a good strategy for implementation in competition training routines for Paralympic athletes to reach their individual goals.*

***Key words:*** *Paralympic sport, spinal cord injury, senior para-athlete, female para-athlete*

## INTRODUCTION

The Paralympic Games began in 1948 in England and the idea of holding this event was to include sport in the rehabilitation of injured World War II veterans (Winnick, 2004). Although the Games had a therapeutic purpose, nowadays they demonstrate the characteristics of high-performance sports (Marques et al., 2014).

The internal training load (ITL) has been defined as the psychological and physiological response during and after exercise, and these responses can be used as an indirect or surrogate measure (e.g., sleeping habits and fatigue), through which ITL and surrogate measures are strongly associated (Impellizzeri et al., 2019).

People with spinal cord injury (SCI) are susceptible to several secondary problems, such as pressure ulcers and urinary tract infections (Kinne et al., 2004). They still require some form of physiotherapy, using Paralympic sport to replace the formal physiotherapy and to improve their health related to quality of life (Groff et al., 2009).

Although there have been several studies on people with SCI and their performance, to the best of the authors' knowledge, there is no study which has investigated internal training load and surrogate measures among Paralympic athletes. It was hypothesised that increasing training load in a senior Paralympic athlete might cause fatigue and injury, that in turn could lead to reduced performance in view of her age and physical condition.

### Objective

The objective of this study was to find whether the relationship between ITL and surrogate measures, assessed by changes in the Heart Rate Variability (HRV) measure, the Wisconsin Upper Respiratory Symptom Survey (WURSS-21), and Pittsburgh Sleep Quality Index (PSQI) of a senior female Paralympic athlete with SCI, over a 16-week period, could show some harm or some gains, towards her success in the sixth edition of the Parapan American Games 2019, in Lima.

# METHOD

### Case Study Design

This is a single case study.

The study subject, 68 years of age, became paraplegic due to a tumor in her spinal column, between T12 and lumbar spine (L1). The injury occurred when she was 21 years old and pregnant. As part of rehabilitation, she got involved in para-sport as a table tennis player. She then went on to participate in the Paralympic Games, first in Atlanta (USA) in 1996, followed by Beijing (China) in 2008 and London (England) in 2012. Her clinical presentation was paraparesis in the sport classification and F5 class.

Ethical approval was obtained from he local ethics committee of the Federal University of Parana in Brazil under the number 2.294.303 and the protocol of Case Report Guidelines (CARE) was followed (Gagnier et al., 2013)

### Procedure

Written informed consent was obtained from the athlete before the beginning of this study.

The athlete was monitored during 48 training sessions, over a period of 16 weeks. The organisation of the training plan was as follows: weeks 1 to 4 = preparatory period, week 5 = tapering, weeks 6 and 7= secondary competition, week 8 = recovery post-competition, weeks 9 to 13 = preparatory period, weeks 14 and 15 = tapering, week 16 = target competition.

### Internal Training Load (ITL)

The (Foster, 1998) protocol was used, with the session rating of the Rating Perceived Exertion measure using a 10-point scale in quantifying the ITL of the athlete. Thirty minutes after ending each training session, the athlete was presented with the 10-point RPE Scale and answered the question: “How was your training today?" Each session the ITL was calculated by multiplying the RPE score and the sum score calculated for a total of 16 weeks (Debien et al., 2018).

**Heart Rate Variability (HRV)**

HRV was measured once a week, before the training programme. The recording time was 5 minutes of R-R intervals (RR*). Polar® H10 heart rate monitor was processed in Kubios HRV® version 3.0.1. The standard deviation of RR* of normal beats (SDNN) and root mean square of successive RR* (RMSSD) were calculated and transformed into their natural logarithm (lnRMSSD). Four variables were calculated: $lnRMSSD_{MONTHLY}$ (vagal activity), $lnRMSSD_{CV\%}$, SDNN: $RMSSD_{MONTHLY}$ (sympathovagal activity) and SDNN: $RMSSD_{CV\%}$ (Honkanen et al., 1998), (Esco et al., 2018).

**Wisconsin Upper Respiratory Symptom Survey (WURSS-21)**

The short version (WURSS-21) was developed to evaluate the negative impact of acute upper respiratory tract infection (URTI) and has been validated with 21 items. A Likert Scale of severity, ranging from 0 to 7, has been used to give a value to each of the 21 the items. The 7-point scale had the following values: no symptoms were experienced = 0, very mildly =1 and 2, mildly = 3 and 4, moderately =5 and 6, and severely =7. The URTI symptoms were recorded once a month. To give a representation of the status of acute upper respiratory tract infection for the entire time span of 16 weeks, all available scores of URTI were averaged (Barrett et al., 2005).

**Pittsburgh Sleep Quality Index (PSQI)**

PSQI is a questionnaire that assesses sleep- behaviour and disturbances over a 1- month period. It contains 19 self-rated questions grouped into 7 items scores, each one weighted on the Scale (0-3) equally. Therefore, global scores range from 0 to 21, and the highest score indicates the poorest sleep quality (Buysse et al., 1989).

**Statistics**

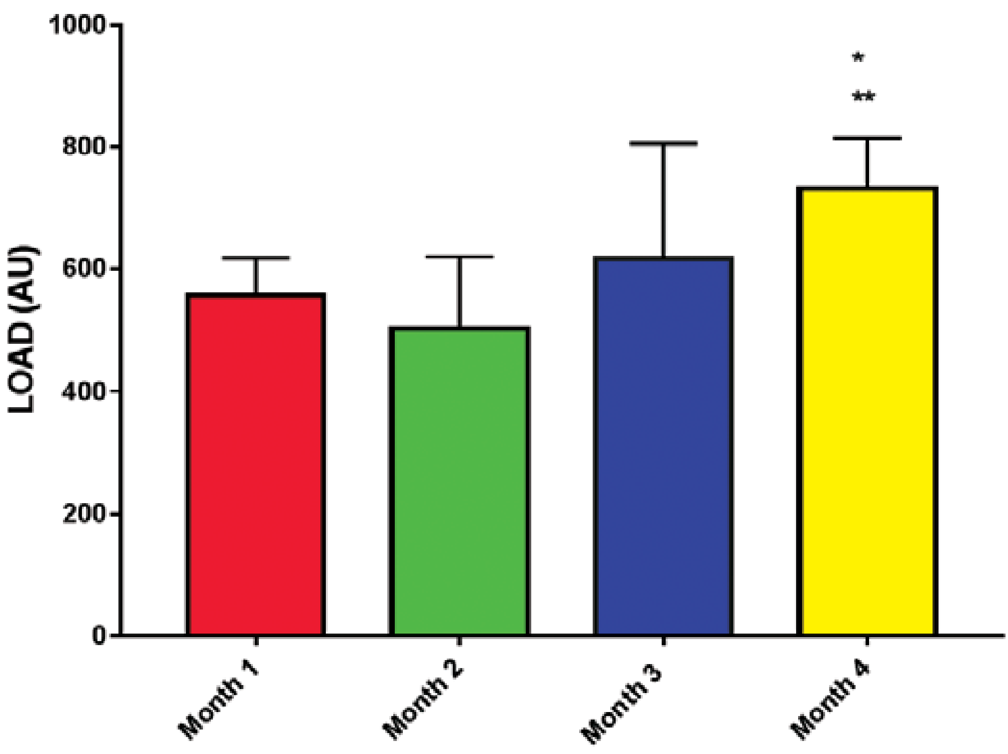
To investigate ITL and surrogate measures, the statistical analysis used was GraphPad Prism Software (version 7.0) and the one-way analysis of variance (ANOVA) with Tukey's multiple comparison tests or Kruskal-Wallis test. It was followed by Dunn's test when a parametric test was not satisfied. Results are demonstrated as mean ±standard error of the mean (S.E.M) and significance was at $p < 0.05$.

## RESULTS

### ITL

The ITL is demonstrated in Figure 1 with a mean and S.E.M with the statistically significant difference among the 4 periods of training (months 1, 2, 3, 4).

**Figure 1: Monthly ITL in a senior female Paralympic Athlete over a period of 16 weeks**




* Statistically significant difference between month 1 and 4p < 0.05.

** Statistically significant difference between month 2 and 4 p < 0.05.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## HRV

The HRV was analysed during the 16-week monitoring of the athlete. The results are presented in Table 1.

**Table 1: The mean of mean HR (heart rate), RMSSD (Root Mean Square) and SDNN (standard deviation of all RR intervals): RMSSD during the 16-week monitoring of ITL**

| HRV | Mean RR* (ms) | Mean R* (bpm) | RMSSD (ms) | SDNN: RMSSD (ms) |
|---|---|---|---|---|
| Month 1 | 919.5 ± 46.66 | 65.75 ± 3.521 | 59.58 ± 14.72 | 0.892 ± 0.153 |
| Month 2 | 1009 ± 27.52 | 59.75 ± 1.75 | 142.0 ± 15.04 | 0.630 ± 0.022 |
| Month 3 | 1019 ± 21.0 | 59.0 ± 1.0 | 218.3 ± 66.15 | 0.650 ± 0.0 |
| Month 4 | 977.5 ± 54.48 | 62.0 ± 3.719 | 158.1 ± 44.05 | 0.702 ± 0.024 |

Values are means ± SM. The differences among the months in each analysis of HRV were considered statistically significant* $P < 0.05$. There was no statistical difference in either mean RR*, mean HR*, RMSSD or SDNN: RMSSD

### WURSS-21

The athlete in this case study had to answer the question about her symptoms of WURSS-21 once a week. The answer was "not sick" = score 0, during the 16-week programme.

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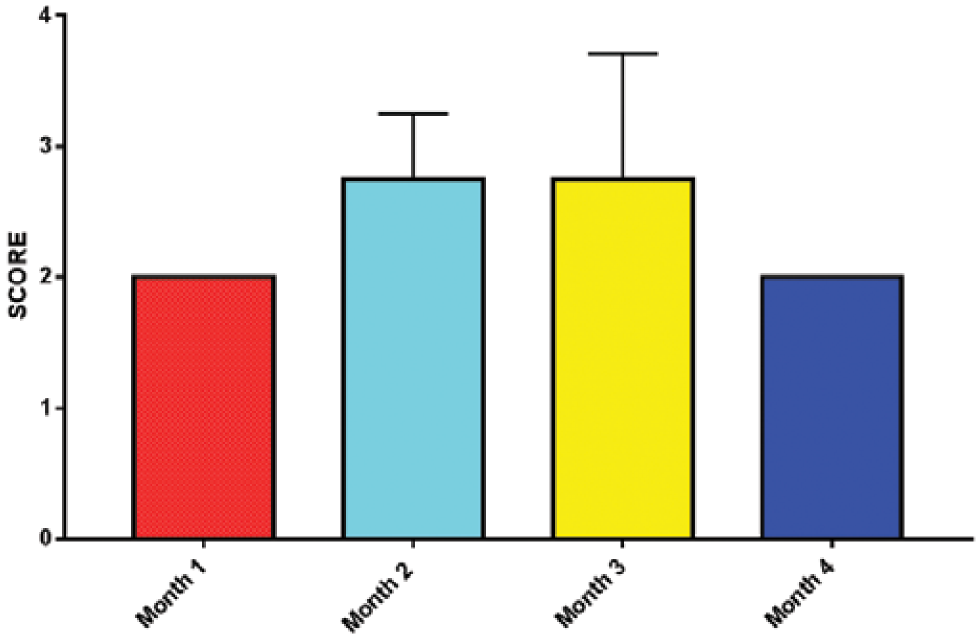
## PSQI

PSQI is described in Figure 2.




PSQI of the athlete was demonstrated monthly, with no statistical difference* p 0.05 during the 16-week monitoring. Values are means ± SEM.

PSQI scores were: 0 - 4 = good quality of sleep, 5 - 10 = poor sleep quality, and>10 = presence of sleep disturbance (Buysse et al., 1989). The numerical score of global PSQI was 2.375 and S.E.M 0.619, indicating good quality of sleep.

## DISCUSSION

It is well established that monitoring ITL in elite athletes can improve their performance (Impellizzeri et al., 2019). To succeed in the Parapan American Games, the senior female Paralympic athlete was invited to be monitored with ITL and surrogate measures for 16 weeks.

The HRV has been used as a simple and non-invasive measure of the autonomic impulses. It appears to be one of the most promising quantitative markers of autonomic balance, and its use has grown considerably in the field of sports science for its high performance evaluation (Buchheit, 2014). Besides, the HRV seems to be influenced by exercise practice, physiological stress, quality of sleeping and some immunological diseases (Rodrigues et al., 2019). Moreover, HRV can be altered by ageing, gender and physical exercise (Reland et al., 2004), and in women, parasympathetic modulation of HRV seems to change, apparently beginning at menopause (Eaker et al., 1993). According to (Paschoal et al., 2006), a significant reduction in the indicative values of parasympathetic activity and increase in heart sympathetic activity has been demonstrated from the sixtieth decade of life. Comparing the results of monitoring the athlete in the current study, with (Paschoal et al., 2006), the parameter of the mean of RR*of this athlete, over 16 weeks, was 11.64% more than that of active women between 51- 60 years of age. The result of HRV based on the mean of RR* from this study, demonstrated that in the case of the senior female athlete the rule of reduction of total power from the sixtieth decade of life, did not apply. Since SCI, menopause and the ageing process can cause the HRV to decline, it is believed that high performance sport, with all surrogate measures presented in this study, might keep the athlete´s HRV in balance.

(Gleeson et al., 2012) were of the opinion that athletes are more susceptible to URTI as compared to the general population. Although sports competition can be linked with a high risk of illness, especially with URTI(Blume et al., 2018) and individuals with SCI are susceptible to secondary problems such as urinary tract infection (Kinne et al., 2004), the data of WURSS-21 symptoms from the Paralympic athlete in this study demonstrated no infection and/or low risk of being ill during the monitoring period.

Sleep has been reported to be one of the best psycho-physiological recovery strategies to be used with athletes (Halson, 2008). Fortunately, according to the PSQI, the athlete did not demonstrate any sleeping problems and had good quality of sleep. Besides, when the months were compared in PSQI, no statistical difference was demonstrated. In contrast, studies with PSQI on other athletes reported the poor sleep quality among this population (Mah et al., 2018) and high prevalence of poor sleep quality among elite Japanese athletes (Hoshikawa et al., 2018).

## Limitation

No previous studies have been found in which Paralympic athletes were assessed with the measures used in the present study. Therefore, it is not possible to make any comparisons of results with other studies.

## CONCLUSION

In light of the findings it might be concluded that, contrary to her age and physical condition, the senior female Paralympic athlete presented minimal fluctuations in the measures HRV, PSQI, and WURSS-21 during the 16-week monitoring period. Since nothing detrimental was observed in the surrogate measures associated with ITL, it might be safe to say that the athlete in this study achieved some progress towards successful symptom-free participation in the sports competition. A new approach to better monitor the performance of athletes with disabilities could therefore be necessary, and monitoring ITL associated with surrogate measures could be a good strategy to implement in sports competition training routines, for athletes to reach their individual goals. To substantiate this, further studies are recommended, that focus on Paralympic athletes of different physical conditions, age and gender.

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