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Original Article

Reliability and Time-of-day Effect on Measures of RSA Test in Young Healthy Physical Education Students

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ABSTRACT

The present study is designed to evaluate time of day effects on fitness repeated sprints by a terrain test and a laboratory test. During the first phase, we analyzed the relative and absolute reproducibility of RSA (terrain) and RSA (labo) on 42 male subjects. The cycle of the test is to run 6 times a distance of 15m × 2, every 20s (±14s of passive recovery). The RSA (lobo) was performed in the same way on a Cycle-ergometer. The relative reproducibility was analyzed by the intra-class correlation coefficient. The absolute reproducibility was however analyzed by the Standard Error Measurement (SEM) and the Smallest Worthwhile Change (SWC). During the second phase, we studied the effect of time of day on performance indexes in RSA tests on 20 subjects. At this point, RSA tests were performed at two different times of the day, morning (8a.m – 9a.m) and evening (18p.m – 19p.m) at a randomized order and on two successive days. The results showed that in the first phase, Wt and Wi were the most reproducible with CCI > 0, 90. In the second phase, the power output increased in the evening (3451,25 ≠ 740,38 vs 3214,11 ± 689,53) but this difference was no longer significant in the next sprints. Taken together, these results suggest that the effect of time of day seems to concern only the performance in the first sprint of RSA regardless of the effort's nature.

Keywords: Diurnal variation, RSA, Reproducibility, Laboratory test, Terrain test, Students

INTRODUCTION

Biological rhythmicity is a fundamental property of living beings, which affects many physiological parameters of human performance (Drust et al, 2005; Kline et al, 2007; Reilly et al, 1997; Winget et al, 1992). The most studied variations are those, which depend on the rotation of the earth on itself, called circadian rhythms (period close to 24 hours).

In the field of physical and sports activities, several works have been devoted to the study of the effect of circadian variability and its desynchronization on the optimization of sports performance (Melhim 1993; Hill and Smith 1991; Reilly and Marshall 1991; Souissi et al, 2002, 2003, 2004; Deschodt and Arsac 2004 and Lericollais et al 2009; Hill et al. 1998).

It is now well established that the force (Taylor et al; 1993; Cldwells et al; 1994; Cllard et al; 2000) and power (Melhim 1993; Hill et Smith 1991; Reilly et Marshall 1991; Souissi et al,2002, 2003, 2004; Deschodt et Arsac 2004 et Lericollais et al 2009; Hill et al 1998; Falgairette et al 2003; Atkinson et al,1993; Coldwells et al, 1994;) and muscle power vary rhythmically during the day. However, the difference between the maximum and the minimum (the amplitude) of these rhythms circadian is very variable; it was generally between 5 and 21.2% following the protocols and muscle groups studied, but in all cases, the peak was always located early in the evening (16-19 hours).

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In contrast, very little data is available on the circadian rhythmicity of the ability to repeat short and intense efforts. This skill has been called by Bishop (2002) RSA or "Repeated Sprint Ability" and by Merry and Cometti (2004) "speed resistance". The stress pattern of a large number of physical activities is characterized by such situations (alternation of bred and intense efforts interspersed with periods of active or passive recovery) such as football, handball, combat sports, etc. tennis…

Several studies have focused on the physiological significance of RSA activity (Spencer et al 2005; Glaister and Al 2005). These studies are anonymous on the fact that the RSA has specific physiological characteristics different from those of an isolated sprint. In both studies, the RSA was evaluated using laboratory tests performed on a cycle ergometer.

To our knowledge, only two researches, prepared by Racinais et al (2005) and Racinais et al (2010), have been devoted to the study of the effect of time of day on RSA.

However, the laboratory assessment of RSA does not appear to be specific to team sports modes of travel. According to Merry and Cometti 2004, the suspension time on the cycloergometer means that the movement performed does not produce that of a real race.

According to Atkinson and Reilly (1996), the rhythmicity of a variable is very much affected by the quality of reproducibility of its measurement tool. For these same authors, reproducibility represents an essential condition to limit the random effects that can distort the results as well as errors in judgment or handling. However, the work of Racinais et al 2005 and Racinais et al 2010 did not verify the reproducibility of their RSA tests.

The reproducibility of both RSA, a laboratory performed on a cyclo ergometer, and an RSA field test presenting the same pattern of effort (the same duration of the effort; the same number of repetitions and the same duration of recovery and the effect of nature of the effort on the circadian variability of final performances on these RSA tests in physical education students specializing in team sports.

Subjects

Forty nine physical education students, specialized in collective sports, volunteered to participate in the study. They were fully informed of the protocol procedures and signed a consent form before participating.

During the first part of the work, 42 students have taken part of the RSAT and RSAL reproducibility study (age, 21, 31 ± 1,42 yrs; height, 176 ± 0.03m; mass, 73,72 ± 11,34 Kg).

In order to have a homogenous group of chronotype view, and to avoid inclusion of "extreme types" subjects were selected as "neither types" on the basis of their answers to the Horne and Ostber chronotype determination questionnaire (1972). All the subjects who took part in the second phase of our work were moderately early in the morning.

Testing Procedures

Repeated sprint ability laboratory and terrain (RSAl & RSAt)

Starting with the Repeated Sprint Ability in Laboratory (RSAl) test, it assesses the athlete's performance evaluation throughout repetition of several maximal sprints. Referring to patterns where the performance of intense exercise is separated by recovery periods which could be crucial during competitions.

The RSAT was preceded by 15min of active warm up followed by 5min recovery. This repeated sprint protocol was conducted as follows: repeat a 30 meters shuttle (2*15m) (~6sec) with departure each 20 second (~ 14sec of passive recuperation between repetitions).

The RSAt final performance was performed according to three factors: the Total Time (Tt), which corresponds to the sum of all the sprints' performance, the Ideal Time (Ti) (Ti= Tbest*6) where Tbest is the best recorded performance (generally the first sprint's performance); and the Index of Fatigue (FI) which was calculated under the Glaister's formula (2005) and which informs about the loss of performance on all sprints. The weaker the IF is, the stronger the subject is when it comes to repeated sprints.

For the second test, the Repeated Sprint Ability occurred in the terrain (RSAl); it consists of carrying 6sec sprints for 6 times each 20 seconds on a cyclo-ergometer.

During the test, the retrieval between sprints was passive. An account down 5 seconds was raised before every sprint aiming at warming the athlete at the exact time of the effort beginning.

The RSAt performance has been expressed as Total Work (Wt) which corresponds to the sum of 6Pp of 6 sprints, the Ideal Work (this index acquired by multiplying the best sprint Pp with 6) and the Fatigue Index (FI) which is calculated through the following formula (Bishop 2002):

During this phase, the body temperature has been measured before the warm up in sitting position after a 15min passive rest using an electronic thermometer (type MT 16991 BMWC, 0.1°C). This index was used as a simple biomarker of effect of time of day.

Statistical Analyses

The statistical analysis of the data was realized using the statistical software SPSS (Version 19 for Windows, Inc, Chicago,IL). The average and the standard deviation were calculated for each measured parameter.

In either part of the study, the distribution normality has been checked through the «Kolmogorov-Smirnov" test. Concerning the hypothesis of average equality, it has been checked by the t of "Student" for paired sample and the test of variance analysis (ANOVA).

Over the first phase of the work, reproducibility of the relative performed tests, RSAt and RSAl, was studied by the coefficient of intra-class correlation (CCI). The absolute reproducibility of the same parameters has been analyzed by the Error Standard Measurement (ESM) or "Standard Error of Measurement" (SEM).

In order to better interpret the ESM, we proceeded in this work to the calculation of the smallest useful variation (PPVU) or "Smallest Worthwhile Change" (SWC).

- If the ESM is lower than the PPVU, the sensitivity of the test to detect a change is said to be "Good";
- If the ESM is equal to the PPVU, then the sensitivity of the test is said to be "satisfactory";
- If the ESM is greater than the PPVU, the test is considered "marginal".

The significance level for all the tests was set a priori at $p < 0.05$.

RESULTS

Relative and Absolute Reproducibility both RSA Terrain Test and RSA Laboratory Test

The results of RSAt show that that the coefficient of heteroscedasticity is statistically non significant ($p > 0.05$) for all indexes. Thus, a logarithmic transformation of the data proved unnecessary (Cooper and al 2005) as displayed on the Table 1.

For the other test, RSAl, for the average performance of our athletes (±ET) revealed almost the same results as the last; the coefficient of heteroscedasticity is statistically non significant. Besides, referring to the results on Table 2, Wt and Wi were the most reproducible index with the CCI≥ 0.90.

The Effect of Time of Day on the Final Performance for the RSAt and RSAl

RSAt

The morning and the evening data for the average performance values in the terrain revealed that the value of Tb (Best Time) decreased significantly during the RSA test terrain from its beginning to the end.

Added to that, the results of the statistical analysis revealed an effect of time of day on the decline in performance ($F = 4.53$; $p < 0.05$). Besides, the Post-hoc analysis has revealed the existence of significant differences between Tt morning and evening ($F = 13,56$; $p < 0.05$) and these differences were not significant between the following sprints.

The FI was affected by the time of day as well; it was more important at night (6,08±1,29) than in the morning (4,43±1,54).

On the other hand, the total time taken to achieve the 6 * 30m was not affected by the time of the day (36,60±1,24 at the morning, 35,96±0,98 in the evening)

RSAl

During the RSAl test the Pp decreased remarkably (the morning: from 775,32±186,30 to 502,86±149,85; the evening: from 821,16±200.32 to 510,96±169,78) which had proven to be affected by the time of the day

Table 1: Results of analyzes of relatives and absolute reliability of RSA test

Indice	ICC	ESM	PPVU
T_{total} (sec)	0,92	0,87	1,09
T_{best} (sec)	0,91	0,76	0,98
FI (%)	0,65	0,91	1,29

T_{total} : Total Time total ; T_{best} : Best time ; IF : Fatigue index ; ICC : Intraclass Coefficient of Correlation Intraclasse ; SEM : Standard error of mesure ; PPVU : Plus Petite Valeur Utile.

Table 2: Morning- evening performances (± ET) of students of RSA test

Time	Sprint 1	Sprint 2	Sprint 3	Sprint 4	Sprint 5	Sprint 6	F	p
Morning	5,93±0,32	5,97±0,22	5,98±0,21	6,16±0,3	6,28±0,29	6,34±0,27	39,98	<0,05
Evenening	5,41±0,27	5,79±0,31	5,91±0,35	6,24±0,15	6,32±0,21	6,41±0,28		

(F=10.01; p<0,05). Besides, the Post-hoc disclosed an important difference between the Pp morning and evening (F= 15.45; p<0.05), yet it declined during the following sprints. The FI was also affected by the time of the day regarding the results on table.

DISCUSSION

Most of the physical education institutes around the world use a multitude of tests to measure performance factors, such as RSA ability. The results of such tests are used to gain more information that can be used in the physical fitness test batteries allowing the entrance of students in athletic schooling institutions

The aim of the present study is to analyze the relative and absolute reproducibility of two RSA tests, one on terrain and the other in laboratory, besides to the effect of time of day on final performances.

The present results prove that these two tests are reproducible if they are expressed as total time (Tt) and the ideal time (Ti) for the field RSA test and as a peak power (Pp) or work total (Wt) for the laboratory RSA test. The nature of the effort did not have an impact on the effect of time of day on the performance in RSA tests. Tt and Wt were stable during the day. FIs increased in the afternoon. Pic and Tb (best sprint of 30 m) were better in the evening. Training process improvement in team sports must go through the analysis and identification of critical performance factors to develop them specifically. To determine the specific physical qualities, an excellent knowledge of the activity and a wise observation are essential (Platonov 1985). The modeling efforts in competition allowed the optimization of training content in several types of team sports (Cardinale 2005; Cometti 2003 Grostiaga et al 2005). Although quantitatively the activity of a player is as an effort mainly aerobic (a significant number of kilometers run during the match), a detailed analysis shows that the pattern of effort is a summation of short, intense and interspersed efforts with periods of passive or active recovery. Thus, a player of team sports must be able to repeat these explosive efforts in time preserving certain qualities such as speed and accuracy that are likely to change the result of a match. In fact, it is in these brief and intense actions that settle the difference in the match: a goal or a point scored after a quick start, an attacker stopped by a keener defender. Thus, for a player of team sports to be effective, he must be quick at repetition. Tests of measuring the ability to repeat sprints are among the most listed in team sports literature field tests, expressing the will of subjects of the field to assess closely what really does the player in completion (Grostiaga et al 2005; Ronnie et al 2005). All RSA tests were defined in relation to three indexes:

- The duration or length of the sprint;
- The number of repetitions;
- The recovery time.

The Duration or Length of the Sprint

According to Spenser et al 2005, the duration of a repeated sprint is on average almost equal to 6 seconds, which justifies the choice for this time in sports (Bushheit 2008; Racinais 2010). In our work, the effort duration in both RSA tests was fixed at 6 seconds.

The Number of Repetitions

The number of repetitions affects significantly the final performance at the RSA tests. Balsom et al (1992) were well knowledgeable on this point. They demonstrated that a 15m- sprint can be repeated 40 times every 30 seconds without losing performance. Whereas, the performance degrades significantly with longer 30 or 40 m distances. Thus the choice of the number of repetitions in a RSA test must be sensible that the variation of this parameter can significantly change the physiological significance of the test. Spencer et al 2004 require a number higher than or equal to three repetitions.

Recovery Type and Duration

Like the number of repetition, the recovery type and duration affect significantly the final performance at the RSA tests. Balson et al (1992) showed that the average power output during a 6 seconds sprint on non-motorized treadmill can be kept constant along 10 repetitions if the recovery is 60 seconds. But when the recovery time is reduced by half, a decrease

in performance is observed on the fifth repetition. Signorile et al (1993) compared the effects of passive and active recovery on the PP and Wt of RSA test laboratory of 6 seconds sprints on a cycle ergometer. They noted that the values of both indexes are more important when the recovery is active. In our work, the recovery time was 14 seconds because of the limited number of repetitions (only 6). For organizational convenience, we made use of passive recovery in the RSA laboratory and terrain tests.

To check if the nature of the effort could affect circadian variability for the ability to repeat short and intense efforts without losing too much quality, we used in our work two RSA tests carried out on a laboratory cyclo ergometer and other in terrain, which are validated by Bouchheit at (2008) for this kind of measurement. Both protocols possess the same model effort, which consists on repeating 5sprints of 6 seconds duration every 20 seconds.

According to Atkinson and Reilly (1996), the rhythmicity in an evaluation test is strongly affected by the degree of reproducibility. They assume that a test, which is not reproducible, may not be an adequate tool for the "trekking" variations in the physical quality evaluated by this test.

Thus, the first phase of our study was devoted to the analysis of relative and absolute reproducibility of RSA test terrain and laboratory. These tests enabled the study of the effort nature effect on the variability of aptitude for repeat short and intense effort without losing too much physical quality for physical education students.

Reproducibility Study of RSA Test

The results of this first phase of <w0078work did not identify statistically significant differences between test performance (test and retest) RSA terrain and laboratory ($p>0.05$; dz:0.01-0.2). The relative reproducibility of these final two tests RSA performance was analyzed by the intra-class correlation coefficient-class (ICC). According to Sirotic et al (2008) ICC> 0.8 is a sign of good relative reproducibility. CCI values presented in Table 3 confirm the results found by Oliver et al 2007. According to them, the RSA test performance is reproducible if it is expressed as a Pic and a Wt for laboratory tests on a cycle ergometer or as Ti and Tt for RSA terrain tests. RSA tests are non-reproducible

Table 3: Results of the reproducibility analysis of RSA test

Index	CCI	ESM	PPVU
Ppic (W)	0,92	0,75	1,03
W_{total} (W)	0,90	0,91	2,12
W_{ideal} (W)	0,91	0,69	1,08
IF (%)	0,72	2,18	1,26

if their final performances are expressed as an FI. In our work the FI remains a non-reproducible index that is assessed by the RSA test terrain or laboratory. The CCI was <0,8. This result does not accord with that of Juliano et al (2010) and Glaister et al (2008) and Wong et al (2011). This discord could be due to the difference in the patterns of the protocols used. Wong et al (2011) used a protocol of 9 × 30 with a passive recovery of 25 seconds duration. The protocol used by Juliano et al (2010) was composed of 7 × 34,2 m with 25 seconds active recovery. Future studies would be interesting to study the effect of the effort pattern structure of RSA test on the reproducibility of the IF.

Absolute reproducibility can be studied by the ESM or the coefficient of variation (CV). The choice of the analysis tool depends on the presence or absence of the data collected in heteroscedasticity (Hopkins and al (2001)). If they are heteroscedastic, the CV is the most suitable tool for the study of absolute reproducibility, but if the data are homoscedastic, the ESM seems to be the most effective way for this analysis (9,39).

Since the data collected for RSA field tests and laboratory were homoscedastic, we chose the ESM to study the quality and repeatability of the tests.

For a better interpretation of the ESM, we used to calculate the smallest useful variation (PPVU) or "Smallesr Worthwhile Change" 5SWC) (Cormack et al (2008), Pyne, DB (2003)).

The FI showed the lowest degree of accuracy and repeatability. For both RSA tests, the ESM was above the PPVU. Hence, the ESM value of the calculated in our study was higher than what Wong et al (2011) revealed. Similarly, in his publications (2009), Oliver gave the same result as ours. According to him the mathematical procedures involved in calculating the FI could be the cause of its poor reproducibility.

The nature of effort seems to have no effect on the FI absolute reproducibility. In our study, the FI remains

irreproducible that is assessed by running or cycling on an ergometer.

Unlike the IF, the other indexes to RSA tests revealed a good accuracy and repeatability. The Pp, Wt, Ti and Tt presented MSEs below their PPVUs. These results conform to those published by Oliver et al (2007). Despite the differences in these protocols, both authors have the same findings for the Pic, Wt, Ti evaluated by a test RSAt and RSAl test. A good reproducibility of Tt and Ti were found by Juliano et al (2010) and by Wong et al (2011).

Effect of Time of Day on Performance Tests to RSA

A detailed description of the circadian variability of ability to repeat sprints requires "trekking" this physical quality over a period of 24 hours. Therefore, in our study, we are interested in the effect of day on this quality, since the training sessions and even competitions occur rarely late at night.

Racinais et al (2010) and Racinais and al (2005) showed that the value of Pp recorded during a cycle ergometer sprint is higher in the evening than in the morning. Similarly to these authors, we found in during the study a significant improvement in Pp and Tb values, which are measured in the first sprints of RSAl and RSAt (775, 32 vs 821.16) and (5.93 vs 5.51) respectively).

Referring to Bernard and al (1998), a sprint is a maximal willing (voluntary) effort. It is responsive and controlled by the central and peripheral neuromuscular factors. Added to that, these factors can affect the diurnal variability of brief and intense efforts' performance. The response time, the speed of conduction of nerve impulses and neuromuscular coordination, may constitute of underlying mechanisms of the diurnal variability of brief and intense efforts' performance. About these factors, Stephenson and Williams add the effect of peripheral factors in this variability. According to them, the increase of the CA++ secretion through the sarcoplasmic reticulum, the evening comparing to the morning, the increase of the myofibrils sensitivity to Ca + + and of the activity of myosin ATPase to the same time of day, may explain the daily variation of the maximum voluntary isometric contraction.

Our results also showed that the PP and Tb were not affected by time of day from sprint 2 to sprint 4. Similar results were published by Racinais and al 2010, and Racinais and al 2005. Bishop and al (2001) proved the existence of positive and significant correlation between the decrease in performance and Pp. Therefore, it appears that the increase of the FI value in the evening (28.92 and 6,08) comparing to the morning (20,13 and 4,43) is the result of the Pp and Tb increase.

According to Racinais and al (2005), the absence of the effect of the hour of the day on the performance for the second, third, fourth and fifth sprints during both tests (RSAt and RSAlab) and on Wt and Tt, confirm Oliver's assumptions (2009). He states that an augmentation in FI in the evening is not a sign of a weaker ability to repeat short and intense efforts without losing too much quality, but rather the mathematical consequence of the increase in the value of Pp.

CONCLUSION

To conclude, findings of the reliability and sensitivity analysis strongly support the use of the RSA scores in physical education students. In addition, in this cohort of young males of high athletic ability, a diurnal variation in first sprint was present with higher performance in the evening compared with the morning.

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