Evaluation of the Level of Alertness with Variations in Reaction Time in Bulgarian Sport Students

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Abstract: *The aim of this study is to evaluate the level of alertness with reaction time test in Bulgarian sport students.*
Materials and methods: Our sample includes 25 sports student, mean age 19.92, recruited from different disciplines from National Sports Academy "Vassil Levski", Sofia, Bulgaria. Reaction time has been assessed twice a day (once in the morning and once in the afternoon) to check if reaction time has a relationship with the level of alertness based on chronotype according to Morningness-eveningness Questionnaire (MEQ). Outcome measures include Vienna Test System (test form S7) and MEQ.
Results: The moderate morning type had a faster reaction time both, in the morning and in the afternoon as compared to the intermediate and moderate evening type (reaction time with and without cue). Intermediate type had the worst reaction time and moderate evening type were in the middle.
Conclusions: The main objective of this study is to find out if the reaction time depends on the level of alertness. It has been found that the participants, which are moderate morning type, indicating high alertness in the morning, have faster reaction time in the morning and in the evening (with or without cue).

Keywords: *Morningness-eveningness questionnaire, Reaction time, Chronotype.*

Introduction

Simple reaction time, the minimal time needed to respond to a stimulus, is a basic measure of processing speed [15]. It is faster with an intermediate level of alertness. Three basic reaction time experiments are known: simple reaction time experiment, recognition reaction time experiment and choice reaction time experiment [6, 13]. In simple reaction time experiments, there is only one stimulus and one response. For instance, a person might be asked to press a button as soon as a light or sound appears [4]. For about 120 years, the accepted mean single reaction time for college-age individuals have been about 190 ms for light stimuli and 160 ms for sound stimuli [4]. But Eckner et al. [2] reported that there is a difference between field (203 ms) and computer test (268 ms) measurements. The reaction time experiment, type of stimulus and stimulus intensity are basic features of a reaction time test, but there are many factors that affect reaction time such as gender, age, level of arousal, vision, fatigue, etc. [6]. Hence, the need arises to evaluate reaction time so that training and/or competition schedules can be timed according to the level of alertness. That will be beneficial in athletes to improve performance and to reduce the risk of injuries.

Methods

The study was conducted in the Laboratory of the Department of Physiology and Biochemistry at National Sports Academy "Vassil Levski", Sofia, Bulgaria in accordance with the research ethical code of the University. Participants from different sports were screened for eligibility and informed consent was taken. The subjects included in this study were between 19 and 25 years old. Total of 41 were screened based on inclusion criteria. The inclusion criteria were: 19-25 years old, in good health (no drug use 2 months prior the measurements), corrected refractive or acoustic errors (if there are such), submission of all tests (in the morning and in the afternoon).

Procedure

The aim of the present study was to evaluate the level of alertness with reaction time test in sport students. The duration of this investigation was 2 weeks. In this period the subjects were examined for the inclusion criteria and baseline data. Demographic and anthropometric (participants' height (cm) and mass (kg) were measured and used to determine their body mass index (BMI, kg/m^2) data were recorded. The participants who met the inclusion requirements completed the Morningness-eveningness Questionnaire (MEQ) [3] (25 from 41). Then the reaction time was checked twice in a day – once in the morning and once in the afternoon using the Vienna Test System (VTS) – S7 (reaction to visual signal, without and with cue). This is a computerized test system widely used in sports sciences [8].

Morningness-eveningness questionnaire

Chronotype was assessed by the standardized Horn-Östberg MEQ. The purpose of MEQ is to determine if the level of alertness, of an individual, is higher in the morning or in the evening. It is a reliable instrument for this assessment (Cronbach's α, r = 0.7). The MEQ is a self-assessment questionnaire which contains 19 closed questions and classifies humans according to their preference toward performing certain activities in particular time of the day. Each answer (*a*, *b*, *c*, *d* and sometimes *e*) has a given number of points (from 16 to 86). Higher number of points determines morningness and lower number of points indicates an evening chronotype. Morning types, which are more alert in the morning, will have 59 scores and above, 41 scores and below indicates evening type (they are more alert in the evening). According to Horn-Östberg [3], there are 5 chronotype groups: definite evening type (16-30 scores), moderate evening type (31-41), intermediate type (42-58), moderate morning type (59-69), and definite morning type (70-86).

Vienna test system – reaction tests – indicators of phasic alertness

VTS is a computerized system that is able to measure reaction time. VTS was developed by Schuhfried GmbH (Moedling, Austria) as a valid and reliable tool for psychological assessment and contains a myriad of tests which are relevant to sport psychology. It is suitable for assessing both ability and personality in athletes, and includes tests of many different constructs such as alertness (state of wakefulness) by measuring simple reaction time for visual (S7) signals [8, 9]. Reaction time is the time that elapses between a signal and the start of the mechanical response movement. The response time is measured in milliseconds. The reaction tests consist of three phases – an instruction, practice and test phase.

The first phase begins by explaining what is to be measured and describing how the black and the golden button on the keyboard are used, when relevant stimuli appear (for S7 – yellow light). The respondent is sitting in front of the monitor and response panel. He/she is asked to place the forefinger of the hand with which he/she writes on the golden key. In test form S7 there are two sub-tests – without and with cue.

The second phase is the practice phase. The purpose of this phase is for the subject to respond correctly to several stimuli and to perform the test correctly.

The third phase is the test itself. The respondent starts the phase himself by pressing the black key from the response panel. The length of this phase is about 8 minutes. 56 stimuli are presented – 28 without cue and 28 with cue (lasting half a second) [9].

The main variables for assessing the level of alertness used in the study are presented in Table 1.

Table 1. Main variables for assessing the level of alertness

Objective variables, ms	**Abbreviations**
Mean reaction time without cue	RT WOC
Mean reaction time with cue	RT WC
Subjective variables	**Abbreviations**
Scores from MEQ	Scores
Chronotype	ChT

Statistical analyses

For assessing the differences between the above discussed variables (Table 1), we divided the respondents into two groups:

- By chronotype – there are three sub-groups: moderate morning type (MMT), intermediate type (IT), moderate evening type (MET);
- By gender – there are two sub-groups: males and females.

All analyses were executed using SPSS for Windows, IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences). Participant characteristics were compared using a one-way analysis of variance (Welch-ANOVA) and post hoc analyses were performed using Games-Howell post hoc test. The statistical significance was set at $p \leq 0.05$. The internal consistency of the MEQ was estimated using Cronbach's α coefficient [5].

Results

Participant characteristics

The general characteristics of the participants are presented in Table 2.

The mean age of all the subjects was 19.92 ± 1. The mean weight, the mean height and BMI were statistically significant (according to gender). According to the chronotype it was found a statistically significant difference in mean height.

Measure of the internal consistency of the MEQ and classification of diurnal phenotype

Cronbach's α coefficient was used to determine the internal consistency of the Horn-Östberg questionnaire and was considered to be satisfactory ($\alpha = 0.7$). All 25 participants completed the questionnaire. The mean questionnaire score was 50.32 ± 7.1. The data are presented in Table 3 as mean ± standard deviation (SD) and as numbers and as percentages in Table 4. The sample of individuals tend to be of intermediate chronotype.

Table 2. General characteristics of the participants divided by sub-groups

Groups	*n*	Characteristics			
		Age, y mean ± SD	Body mass, kg mean ± SD	Height, cm mean ± SD	BMI, kg/m^2 mean ± SD
Gender					
Male	13	20.1 ± 1.1	78.7 ± 10.7	182.9 ± 8.2	23.38 ± 1.7
Femal	12	19.75 ± 0.9	61.25 ± 7.9	172.1 ± 4.27	20.58 ± 2.5
p		> 0.05	0.000^a	0.000^a	0.003^a
Chronotype					
MMT	2	20.5 ± 0.7	59 ± 11.3	171 ± 0	20.21 ± 4.24
IT	19	19.95 ± 1.1	69 ± 11.2	176.5 ± 7.2	22.04 ± 2.49
MET	4	19.5 ± 0.6	81.75 ± 13.7	187 ± 10.9	23.25 ± 1.26
p		> 0.05	> 0.05	0.033^a	> 0.05

^{a} indicates statistical significance ($p = 0.05$)

Table 3. Classification of diurnal phenotype and mean scores for all participants

Chronotype	*n*	Minimum	Maximum	Mean	SD
MMT	2	61	64	62.50	2.12
IT	19	44	58	51.57	3.89
MET	4	35	41	38.25	2.75

Table 4. Chronotype distribution presented as numbers and as percentages (comparison between male and female)

			Chronotype			Total
			MMT	**IT**	**MET**	
Gender	**Male**	Count	0	10	3	13
		% gender	0%	76.9%	23.1%	100.0%
		% chronotype	0%	52.6%	75.0%	52.0%
	Female	Count	2	9	1	12
		% gender	16.7%	75.0%	8.3%	100.0%
		% chronotype	100.0%	47.4%	25.0%	48.0%
Total		Count	2	19	4	25
		% gender	8.0%	76.0%	16.0%	100.0%
		% chronotype	100.0%	100.0%	100.0%	100.0%

According to the mean scores from MEQ there was no difference in chronotype distribution when comparing participants by gender. There was no correlation between chronotype and age for the respondents group as a whole. This finding was most likely due to the small sample size of the group of individuals assessed in this study.

Chronotype and reaction time

All participants were evaluated for their reaction time in the morning and in the afternoon. Data analysis of variance by chronotype and reaction tests were conducted, and are represented as mean values, standard deviation and *p*-value in Table 5.

Table 5. Comparison of chronotype groups by reaction time measured in the morning and in the afternoon

Reaction time – S7, mornings, ms	***n***	**Mean**	**SD**	***p*-value**
MMT	2	WOC = 226 WC = 250	8 25	0.004[a]
IT	19	WOC = 292 WC = 278	39 56	
MET	4	WOC = 268 WC = 257	64 44	
Reaction time, afternoons, ms	***n***	**Mean**	**SD**	***p*-value**
MMT	2	WOC = 252 WC = 213	23 7	0.009[a]
IT	19	WOC = 302 WC = 262	68 45	
MET	4	WOC = 284 WC = 250	59 26	

[a] indicates statistical significance ($p \leq 0.05$)

As Table 5 shows, there is a statistically significant difference between the mean reaction time of the without cue group, estimated in the morning (p = 0.004), and that with cue estimated in the afternoon (p = 0.009). But we found no statistical significance with the evening type and afternoon reaction time ($p \geq 0.05$). The within group comparison of the three chronotype groups was done with Games-Howell post hoc test. When the morning type was compared with the intermediate type in the morning (reaction time without cue), it showed statistical significance with a $p \leq 0.05$ (p = 0.001). There was statistical significance with a $p \leq 0.05$ and when the morning type was compared with the intermediate type in the afternoon (reaction time with cue), p = 0.003. When compared with the evening type there was no statistical significance with a $p \geq 0.05$. The same results were found when the intermediate type was compared with the evening type. So the morning type had a better reaction time than the other groups except in the morning and afternoon. When gender groups were compared (using "t"-test) no statistical significance (with a $p \geq 0.05$) was found.

Discussion

In the present study, the reaction time checked in the morning matched with the level of alertness that is morning type according to MEQ. Appelle and Lawrence [1] found that simple reaction time correlates with the level of alertness. The moderate morning type had also better reaction time in the afternoon. Therefore, phasic vigilance (the exogenous component of alertness) was activated with the presence of a warning tone. However, the reaction time evaluated in the afternoon did not match the evening type of MEQ. It is possible the selected test time may have affected the results. The afternoon testing took place between 14:00-18:30 h, not after 19:00. This is usually the time when academic subjects are taught and it was hoped that will encourage students to participate voluntarily. Another possible reason for the results may be, that the students took the test for the first time. According to Welford (1980) [13], reaction time also depends of arousal. With the intermediate level of alertness reaction, time tends to be faster. Since the reaction time was checked in the afternoon, the participants may have been too relaxed, or too tensed, which led to longer reaction time. Another explanation may be, that moderate evening types did not benefit from the alerting cue, nor in the morning, nor in the evening.

In the study conducted by Song and Stough [11], morningness participants performed worse in the morning, and eveningness participants performed worse in the evening. In our study we noticed that morningness respondents performed better in the morning whereas evening type participants could not show better results in the afternoon. One reason may have been that the respondents have suffered from social jetlag (misalignment between the internal circadian clock, external time cues, and social obligations) thus giving a longer reaction time. The fact that many people in our society shift their sleep and activity times several hours between the work week and the weekends is comparable to jetlag (misalignment between the internal circadian clock and external time cues when people quickly change time zones) [7, 10, 14].

In this paper it was also found that there was no statistically significant difference between male~~s~~ and female reaction time. It was noted in one study, Welford (1977) [12], that women participating in driving and fast sports could show similar results as in our study.

As the VTS is easy to use, it would be a fast and non-invasive tool for estimating reaction time. MEQ can be used to quickly assess the alertness of athletes and to report training sessions depending on their level of vigilance. Major limitation of this study was the small sample size and the time selected for measurements.

Conclusion

The main aim of the study was to find out the relationship between reaction time and level of alertness. It was found that respondents who were of moderate morning type indicating high alertness in the morning had better reaction time when evaluated in the morning. But they had better reaction time in the afternoon too, which indicates that phasic alertness compensates for the decrease of tonic alertness (when alerting cue is presented). The moderate evening type did not show better reaction time in the afternoon compared to moderate morning type indicating accumulated sleep debt (when forced to wake up early in the morning, for example 6:00-7:00 o’clock).

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