Original Article

Diurnal performance of university students' chronotypes

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ABSTRACT

The aim of the study was to investigate the differences between chronotypes of university students ($n = 19$) during morning and evening physical performance parameters: reaction time (RT), tapping frequency (TF) and jump abilities (JA). The results did not show differences between a chronotype's morning vs. evening performance (RT: $F_{(2.16)} = 0.279$, $p > 0.05$, $\eta^2 = 0.03$ vs. $F_{(2.16)} = 0.255$, $p > 0.05$, $\eta^2 = 0.03$; TF: $F_{(2.16)} = 0.869$, $p > 0.05$, $\eta^2 = 0.10$ vs. $F_{(2.16)} = 0.402$, $p > 0.05$, $\eta^2 = 0.05$; SJ: $F_{(2.16)} = 0.136$, $p > 0.05$, $\eta^2 = 0.02$ vs. $F_{(2.16)} = 0.022$, $p > 0.05$, $\eta^2 = 0.002$ and CMJ: $F_{(2.16)} = 0.068$, $p > 0.05$, $\eta^2 = 0.01$ vs. $F_{(2.16)} = 0.051$, $p > 0.05$, $\eta^2 = 0.01$). There were no differences ($p > 0.05$) between groups of chronotypes from the point of view of diurnal performance. It follows that it will not be important when our examined group – young people (university students) will realize the physical activity (concerning mainly RT, TF and JA) from the point of view of time of day (despite of different chronotypes). **Key words:** EVENING PERFORMANCE, JUMP ABILITIES, MORNING PERFORMANCE, REACTION TIME, TAPPING FREQUENCY.

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INTRODUCTION

Sport chronobiology deals with examination of athletes´ performance and time "rules" respect. It also presents potentiality of increasing of sport performance. Athlete´ biorhythm is the aspect thanks to which we can make training more effective. Biorhythms are specific and individual for each human-being and they correspond with current modern trends of individualization of sport training. One of the main aim of the sport chronobiology which deals with athletes´ performance from the point of view of time is to detect optimal time periods and cycles of development of physical pre-conditions. Diurnal rhythms are the most examined sphere of sport chronobiology – examination of performance during light part of the day. Body temperature is one of the most significant endogenous indicator of organism´s readiness. The curve of body temperature can be copied by athletes´ performance (Baxter and Reilly, 1983) but in some cases this fact was not confirmed because of the influence of another factors (Reilly et al., 2007). In general, it is possible to state the relationship between body temperature and performance (Waterhouse et al., 2005; Hayes, Bickerstaff and Baker, 2010). Neiva et al., 2014 a, b, and McGowan et al., 2017 examined influence of warm-up on performance in detail. Diurnal rhythms are components of circadian rhythms and they both are connected with the term chronotype – preference to particular part of the day. Each individual belongs to a specific chronotype (morning, evening, or, respectively, neither) that can influence their physical performance during the day. The term chronotype is an inseparable part of the term "circadian rhythm" which is the period that lasts approximately 24 hours (Aschoff, 1990, 1995 and 1998; Arendt, 1998; Zeman, 2009). The chronotype problem has been examined and researched in many scientific branches and fields mainly in psychology where this term is compared with personal (temperament features and characteristics) and with the shift work (Kitamura et al. 2010; Abe et al. 2011; Tzischinsky and Shochat 2011; Biss and Hasher, 2012; Konrad and Jankowski, 2012). Knowledge of chronobiology has been applied also in sports and sport sciences where the studies monitor and diagnose general physical activity. Henst et al. (2015) examined the relationship between chronotype and diurnal performance of marathon runners from the Netherlands and compared them with the chronotypes and diurnal performance of marathon runners from South Africa. The start time of the marathon differs in these countries (South Africa: 6.30, Netherlands: ±11). This earlier start time can influence chronotype because South African athletes are more morning oriented than Dutch runners. Similar results were presented by Edwards et al. (2005) and Kunorozva, Roden and Rae (2014) who denoted the relationship between chronotype and diurnal performance, finding that workload performance was for morning-types cyclist harder in the evening than in the morning hours. Schaal, Peter and Randler (2010) compared the relationship of chronotypes to physical activity (i.e. their level of interest in physical activity, whether they realized it or not and at what time they realized it). They determined that morning chronotypes realized the physical activity regularly in comparison with evening chronotypes. These results are also confirmed by the research of Muro et al. (2012).

Our study examined whether there are differences in morning and in evening performances among various chronotypes in a sample of university students. These differences are monitored on parameters of an individual's ability to react (reaction time to various directions, tapping frequency of the lower limbs and jump abilities).

MATERIAL AND METHODS

Participants

The experimental sample consisted of university students (n = 19, age = 21.3±2.2 years), who attended the first and the second level of university studies during the academic year of 2014/2015. Students of physical education (i.e., sports) study programmes were not included in this research because these types of students were more likely to be of a moving stereotype. Both women and men participated in this research. The minimal criterion for each student to be included in the evaluation was to participate minimally in three mornings and three evening measurements and from five mornings and five evening possible measurements.

Organizing

Measurements of examined parameters were recorded during the week from Monday, January 26th, to Friday, January 30th in the academic year of 2014/2015. Measurements were realized in the Diagnostic Laboratory in controlled conditions. Diagnostics of diurnal performance were realized in two-time intervals: in the morning from 8.30 – 10.00 a.m. and in the evening from 4.30 – 6.00 p.m. Five morning and five evening measurements were realized from which we calculated the diurnal-mean of morning and diurnal--mean of evening performances of examined students. Diurnal performance was diagnosed and measured through the following parameters: reaction time to the various directions (RT), tapping frequency (TF) of the lower limbs and jump abilities (squat jump – SJ and Countermovement jump – CMJ). Before each morning measurement we examined the length of sleep, subjective feelings and the quality of sleep of the students. The fatigue level was examined before both morning and evening measurements. Students agreed with publication of the results for scientific purposes. All subjects who performed tests had not undergone any surgery on their lower extremities and did not undergo any exhausting physical load the two days before testing. All tested subjects were notified of the content and implementation of the testing procedures and endorsed it with their signatures. This research was approved by the Ethical Committee at competent university. Measurements were carried out in accordance with the ethical standards of the Declaration of Helsinki and the ethical standards in sport and exercise science research (Harriss and Atkinson, 2011).

Chronotype *identification*

A standardized questionnaire was used for identifying chronotypes (Horne and Östberg, 1976). The chronotype was assigned to points which were achieved in the questionnaire according to the following scale: definitely morning chronotype, moderately morning chronotype, neither chronotype, moderately evening chronotype and definitely evening chronotype (Horne and Östberg, 1976).

M*easuring procedure*

The reaction time to various directions was measured through the device FiTRO Agility Check (FiTRONiC, Bratislava, Slovak Republic), which consisted of four contact mats fixed and situated on the floor and connected to a computer. Mats were placed into the shape of a square with external sides measuring 1.2 m. Before measurement each student took up a standing position in the middle of the mats. The student´s task was to react to the visual stimulus on the computer screen situated 3 m in front of the mats. According to the localization of the visual stimulus the student had to perform a particular movement (front right, front left, rear right, rear left), which instructed the student to touch the particular mat with a particular lower limb as fast as possible according to the localization of the stimulus on the screen. Left mats had to be touched by the left lower limb and right mats had to be touched by the right lower limb. Students took up standing position after each touch of the mat by a particular lower limb and waited for the next signal. The signal was presented by a blue circle on a white background with a diameter of 10 cm. The reaction time in milliseconds (ms) was calculated as the mean of 20 visual signals generated randomly within a time interval of 500 to 3000 ms on the computer screen to the four directions according to mat placement (rear left, rear right, front left, front right).

The tapping frequency (TF) of the lower limbs was measured by the device FiTROtapping (FiTRONiC, Bratislava, Slovak Republic) which consisted of two contact mats fixed and placed on the floor and interfaced with the computer. Before the measurement, a student took up a standing position behind the mats. The student´s task was to alternately touch the right and left mat with their left and right lower limb, respectively, as fast as possible (do maximal contacts with mats), during 6 seconds. The result of one measurement of the tapping frequency test was the number of contacts of both lower limbs on the mats of the device FiTROtapping (FiTRONIC, Bratislava, Slovak Republic) lasting 6 seconds. The measurement was realized twice. We recorded the better result from the two realized experiments.

Jump abilities were measured by two tests: Squat jump (SJ) and Countermovement jump (CMJ) through the device Myotest PRO (Myotest, Switzerland). The result of one measurement was the mean height of three best vertical jumps from five consecutive realized vertical jumps in cm with an accuracy of 0.1 cm. Students participated in training tests on all the devices before each test and warm-up.

Statistical analysis

In the present study we used a within periphrastic characteristics of descriptive statistics arithmetic average (x) from position measures and standard deviation (SD) for variability measures. One-way analysis of variance (ANOVA) was used to examined and diagnose the differences between the morning and the evening performance of identified chronotypes from the point of view of examined physical abilities (RT, TF, SJ, CMJ). The probability of a type I error (alpha) was set at 0.05. The effect size coefficient was assessed using “Eta Squared – η^2”, calculated as the common ratio of intergroup and the total amount of squares was interpreted as small effect = 0.01, medium effect = 0.06, and large effect = 0.14. Statistical analysis was realized with IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences) software.

RESULTS

Definitely morning and definitely evening chronotypes were not identified in our sample. Moderately morning and moderately evening chronotypes were identified in three cases. The neither chronotype observed in the majority of students, specifically in 13 students.

The main aim of the research was to diagnose and monitor the differences between morning and evening performances of identified chronotypes with four chosen parameters in a sample of university students (RT, TF, SJ and CMJ). The morning and the evening performances presented in table 1 and table 2 was calculated as the mean performance of all subjects from particular morning and evening measurements during examined periods. The evaluation contains each student´s performance from each day who attended a minimum of three morning and three evening measurements out of five possible morning/evening realized measurements during the examined period.

ANOVA results did not present any significant difference among chronotypes in the examined parameters in the morning performance. The coefficient of effect size presented a medium effect only in the TF parameter while the coefficient of effect size in the rest of the parameters presented a small effect (Table 1).

A significant difference was not identified and diagnosed in the evening performance group (Table 2). A one-way ANOVA found no significant difference in a chronotypes´ performance in all examined parameters (RT, TF, SJ, CMJ). The coefficient effect size presented a small effect in all cases.

Table 1. Statistical evaluation of differences between the mean morning performance of university students´ chronotypes (n = 19) in monitored parameters.

MORNING PERFORMANCE						
Parameter	Chronotype and performance			Statistical analysis		
	MM	N	ME	One-way ANOVA	Effect size (ES)	
	Mean±SD	Mean±SD	Mean±SD		ES value	ES level
RT	661.7±67.3	716.2±112.8	702.3±152.3	$F_{(2.16)} = 0.279, p > 0.05$	0.03	small
TF	62±3	59±7	55±6	$F_{(2.16)} = 0.869, p > 0.05$	0.10	medium
SJ	27.6±6.6	25.9±4.5	25.9±7.9	$F_{(2.16)} = 0.136, p > 0.05$	0.02	small
CMJ	29.8±7.3	28.3±6.2	28.0±8.9	$F_{(2.16)} = 0.068, p > 0.05$	0.01	small

Legend:
SD – standard deviation; MM – moderately morning; N – neither chronotype; ME – moderately evening chronotype; RT – reaction time to various directions; TF – tapping frequency of lower limbs; SJ – squat jump; CMJ – countermovement jump

Table 2. Statistical evaluation of differences between the mean evening performance of university students´ chronotypes (n = 19) in monitored parameters.

EVENING PERFORMANCE						
Parameter	Chronotype and performance			Statistical analysis		
	MM	N	ME	One-way ANOVA	Effect size (ES)	
	Mean±SD	Mean±SD	Mean±SD		ES value	ES level
RT	648.3±64.2	693.5±98.2	689.5±129.8	$F_{(2.16)} = 0.255, p > 0.05$	0.03	small
TF	62±2	61±7	57±9	$F_{(2.16)} = 0.402, p > 0.05$	0.05	small
SJ	27.1±5.5	26.4±4.7	26.6±8.0	$F_{(2.16)} = 0.022, p > 0.05$	0.002	small
CMJ	29.9±7.6	28.7±5.9	28.4±9.0	$F_{(2.16)} = 0.051, p > 0.05$	0.01	small

Legend:
SD – standard deviation; MM – moderately morning; N – neither chronotype; ME – moderately evening chronotype; RT – reaction time to various directions; TF – tapping frequency of lower limbs; SJ – squat jump; CMJ – countermovement jump

DISCUSSION

A chronotype´s identification is standardly realized by questionnaires. One of the most frequented questionnaires for a chronotype´s identification is the questionnaire by Horne and Östberg (1976). Our study focused on whether the identified chronotype according to the questionnaire will correspond to diurnal performance in our sample consisting of university students.

The first task of our study was determining a chronotype´s identification. The neither chronotype was the most dominant and the most frequent type in our sample. This fact can be explained by the assumption that university students do not have an organized time stereotype. The university students do not have regular timetables or schedules during the day. They are not forced to go to work or to do house holding (tidying). Their lives are influenced by school which definitely differs from high school organization because the lectures and seminars start during different hours throughout the week. Our sample of university students were not interested in sports. That is why we cannot predict any time-moving stereotype. What we observed in the examines and diagnoses was a balanced diurnal performance. We did not find any significant difference in monitored and examined parameters of diurnal performance among the chronotypes. The reason may be due to the fact that definitely morning and definitely evening chronotypes were not identified. We can state that definitely morning and definitely evening chronotypes have higher preconditions of different and nonidentical physical performances during the day. The research by Atkinson et al. (2005) examined better evening (afternoon) performance in morning-oriented athletes (n = 8, age = 24.9±3.5 years) in comparison to the morning performance. Barbosa and Albuquerque (2008) examined the explicit memory of undergraduates (n = 68). They did not diagnose any significant difference from the point of view of a chronotype's influence, but they diagnosed the training time-of-day effect for those subjects who trained in the afternoon. Brown, Neft and LaJambe (2008) divided young athletes (n = 16, age = 19.6±1.5 years) into three groups (morning, neither and evening chronotypes). Their performance was examined and diagnosed in the morning hours from 5.00-7.00 a.m. and in the afternoon from 4.30-6.00 p.m. The authors did not find any significant performance difference according to the chronotype´s preference and they stated that their results and performance could be influenced by training and the time- stereotype.

We are aware of the limitations of our research. We are aware of the small number of examined subjects which very noticeable limits the result's objectification. Despite of this fact we realized variance in statistical analysis with the effect size coefficient. Another limit is also an unequal number of students´ chronotypes (moderately morning chronotype: n = 3; neither chronotype: n = 13; moderately evening chronotype: n = 3). Each group consisted of men and women, but for further objectification, it would be appropriate to realize research only with men and women separately, or we would reanalyse the results individually for men and women.

There are many recommendations for future research with similar a design. If it is possible, we would recommend choosing equal number of chronotypes, mainly definitely morning and definitely evening chronotypes. It is important to note that definitely morning or definitely evening chronotypes are very unique chronotypes among university students.

Focused examined group of the study was the young population (young adults) - university students. It will be necessary to broaden our research among all age groups to detect and examine all connections between chronotype and diurnal performance.

The aim of this study was to examine the difference between morning and evening performances among various chronotypes from a sample of university students. The performance was examined through a number of parameters, including reaction time to various directions, tapping frequency of the lower limbs and jump abilities. In the future, it will be necessary to examine endogenous variations of cortisol and melatonin levels and core temperature and analyse them in relation to diurnal performance and the identified chronotype.

Elimination of mentioned limits can objectify results and conclusions in the future.

CONCLUSIONS

Knowledge of chronotype and physical performance can be a significant indicator in the planning of difficult activities and periods of rest during the day. Our study found that that the majority of students tend to be neither chronotype. Only three students were observed to be moderately morning and only three students were observed to be moderately evening chronotypes. Definite morning and definite evening chronotypes were not identified in our sample. The statistical analysis did not show any significant differences between a chronotype's morning/evening performance in the examined and monitored parameters of physical performance (reaction time in various directions, tapping frequency of the lower limbs and jump abilities). If we want to formulate conclusions and recommendations it is necessary to take study´s limits into consideration mainly the low number of moderately morning and evening chronotypes. Results of our study show that it will not be important when our examined group – young people (university students) will realize the physical activity (concerning examined variables in our study) from the point of view of time of day (despite of different chronotypes). Despite of the fact, that our examined group did not contain athletes, the results can be helpful for trainers, coaches, fitness trainers who are interested in chronotype problem.

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