

SLEEP QUALITY AND CHRONOTYPE DIFFERENCES IN CORRELATION TO THE BALANCE CONTROL IN JUVENILE ELITE SPEED SKATERS

Pavel KULMA

Abstract

Sleep is one of the main tools of regeneration, thanks to which physical and psychological parameters are restored and thus balances the negative impact of stress on the human body. The aim of the study is to analyze sleep quality and chronotype differences in correlation to the balance control in juvenile elite speed skaters. For the research survey it was selected 20 speed skaters (age average 17.6 years) from four elite Czech speed skating clubs. The following methods were used: content analysis, Life Rhythm and Sleep Questionnaire, University of Pittsburgh Questionnaire on Sleep Quality (PSQI), and a battery of functional balance tests. The measured data were analyzed by descriptive statistics using numerical and graphical methods, absolute and relative frequencies. The analysis of the results showed a positive correlation between the M-E score and the performance in the functional balance tests, and also showed a significant difference in the Bass test between men and women. Furthermore, it was found that men achieved a lower M-E score than women. Deteriorated level of mental health was found in 10% of the examined speed skaters. The research survey thus showed that the global trend of today's society, which is a strong inclination to the evening typology, also applies to juvenile elite athletes, which is an undesirable phenomenon in terms of balance control and performance in speed skating. The results of the presented study may be useful for training focus of coaches or athletes.

Keywords

Balance skills, morning-evening chronotype, sleep quality, sleep preferences, speed skating.

1. INTRODUCTION

Sleep is one of the basic human needs for maintaining overall health and fitness. Research confirms that there is a relationship between sleep and food intake, short sleep duration can cause endocrine changes including lower leptin levels, glucose tolerance and insulin sensitivity. At the same time, there is an increase in the level of the hormone ghrelin, which has a direct effect on our feeling of hunger and our appetite. Some studies also confirm the connection between poor quality sleep and specific effects on behavior, such as a higher prediction of sedentary behavior. Food intake compared with a lower volume of physical activity (Cao, Zhu, Sun, Jing, 2019).

Physical activity right before going to bed can result in poor sleep quality. For example, athletes very often train to increase their performance and achieve the best possible results. By doing so, however, they expose themselves to the risk that the effect will

manifest itself in the opposite way, and this can lead to overtraining syndrome. Studies have shown that poor sleep quality is also a symptom of overtraining. Therefore, we should pay sufficient attention to regeneration, when sleep is one of the best methods of regeneration (Zhao, Tian, Nie, Xu, Liu, 2012).

In the interests of the best possible performance in sports, high demands are placed on the athlete, and the level of stress also increases at the same time. From the point of view of biological and psychological adaptations, a certain level of stress is also desirable, but we should also keep in mind that there is a limit to everything and an excessive level of stress caused by high intensity, frequency, volume and duration of the training process can have the opposite effects, which are manifested negatively on human health and performance (Kellmann, Beckmann 2018).

Poor sleep quality even increases stress levels during the following day by 4.7 times compared

to people with good sleep quality (Herawati and Gayatri 2019). Kim et al. in his 2019 study observes the effects of sleep on stress levels. His results point to the fact that people who sleep an average of about 6 hours a day, which is much less than the National Sleep Foundation's recommendation, feel more stressed. Even young people who sleep less than 8 hours a night experience higher levels of stress compared to older people who sleep the same amount of time. A higher level of stress is therefore a strong predictor of poor sleep quality, therefore it is advisable to monitor and evaluate sleep parameters for athletes, which can indicate changes in states and possibly reveal the risk of changes (Biggins, Cahalan, Comyns, Purtill, O'Sullivan, 2018). Thanks to the great increase in electric lighting in the 20th century and the uncontrollable increase in the use of modern technology during the 21st century, for the first time in the history of development, humanity began to be exposed to bright and unnatural light during the night, either from screens or from street lights that shine for a long time after sunset. This entails, among other things, potential health risks. Our internal circadian rhythm can be disrupted, not only sleep can be affected, but it can also contribute to a number of other health complications (Šmotek, Kopřivová, Soš, 2016). The circadian rhythm is primarily controlled by the suprachiasmatic nuclei of the hypothalamus, which are called biological clocks. The circadian rhythm is aligned with the conditions in which a person lives. The main synchronizer is light. Information about light intensity is sent from the retina of the eye to the suprachiasmatic nuclei. Information about light conditions is further transmitted to the pineal gland. When it gets dark, the pineal gland starts to secrete the hormone melatonin, giving the body a signal that it's time to sleep. Conversely, when it is light, melatonin production decreases (Kassin, 2007). The state of consciousness is also dependent on a person's body temperature, the higher the temperature, the more the organism prepares for activity, and conversely, when the temperature drops, there is a period when the organism prepares for sleep. In addition to the already mentioned melatonin, the hormone cortisol also affects activity. On the contrary, it is necessary for the organism in the activity phase. Its secretion

therefore increases in the second half of the night and reaches its maximum in the morning around 8 o'clock (Thirion, Callamel, 2013).

Speed skating is a sport with a long history. The International Skating Union (ISU) is actually the oldest international winter sports federation, founded in 1893. Long track speed skating (classic speed skating on a 400 m long oval, speed skating is further divided into short track speed skating, hockey stadium - short track) has been in the Olympics since 1924 and gives today's competitors the potential to win twelve gold medals at the Winter Olympics. Individual speed skating events can be classified into sprint (500 and 1000 m), middle distance (1500 m) and long distance (3000, 5000 and 10000 m). In addition, there are all-around championships where performances over four different distances are added together to determine the overall best performance. The aim of each of these competitions is to cover a given distance as quickly as possible, i.e. to achieve high mechanical performance and reduce frictional losses. Which characteristics determine the mechanical power achieved and the power lost due to frictional forces is an important topic of research in scientific literature. The special technique of speed skating makes this sport an interesting sport from a scientific point of view.

In speed skating, the total performance is the product of the leg's rebound work and the frequency of these rebounds. Work per rebound appeared relatively more important than frequency of rebounds, as faster and slower skaters differed mainly in rebound work but not rebound frequency. Although rebound frequency was not discriminating for performance, it primarily regulates skating speed (Orie, Hofman, De Konig, 2014).

Speed skating is itself a specific movement combining many different movement activities. The actual movement of skaters is a complex physiological process containing elements of dexterity as well as elements of speed, endurance and strength. The group of coordination abilities includes, for example: balance, reaction, rhythm, orientation in space, estimation, etc. All these abilities are an important and integral part of a successful speed skater. In practice, they are applied, for example, as follows: balance when skating on one leg,

reaction to the starting shot, rhythm of individual steps while riding, orientation on the track in relation to the start, goal, coach, etc., estimation of rotations, etc. To maintain balance in designated positions we use the body with the ability to balance, these abilities undoubtedly include a high level of the vestibular apparatus, visual senses and proprioceptors. The ability to balance is best developed or trained using isometric exercises focused on postural muscles. Another of the methods used is exercise on balance surfaces, training of the vestibular apparatus and complex balance exercises (Měkota, Novosad, 2005).

2 AIM, HYPOTHESES

The aim of the presented study is to analyze the quality of sleep and sleep preferences of a monitored group of speed skaters with regard to the functional ability to manage balance and to compare the data obtained.

Based on the established goals, tasks and analysis of literary sources, the following hypotheses were formulated:

H1: Monitored men achieve a lower M-E score than women.

H2: Monitored women achieve better results in the Bass test.

3 METHODS

3.1 Subjects, Procedure

The research group consisted of 20 speed skaters in the age range of 14-30 years. Of this number, 12 speed skaters (8 women and 4 men in the age range 16-30 years) were at the top level as representatives, participating in the World Cup or World Championship. The rest of the research group consisted of 8 speed skaters (4 women and 4 men in the age range of 14-20 years) at the performance level, participating in international and national competitions. Measurements took place at sports camps. Including criteria were regular training of the subjects and absence of injury or illness.

Content analysis

For the presented study we used methods of analysis, synthesis, induction and deduction

as well as causal and operational thinking. A synthesis of evidence and a critical and reproducible summary of the results of available publications on the subject were performed as well.

Diagnostics

For the purposes of the research investigation, a battery of the following diagnostic methods was compiled:

- **Life rhythms and sleep habits questionnaire** (Harada, Wada, Tsuji, Krejci, Kawada, Noji, Nakade, & Takeuchi, (2016) The questionnaire is developed and focused on the circadian rhythms and habits of athletes, including the sleep pattern. It consists of 33 questions, which are divided into 4 parts. The first part is focused on sleeping habits, the second part is focused on circadian typology with the calculation of the M-E score, the third part is focused on eating habits and the fourth part is focused on the level of mental health by calculating the M-Z score. The M-E score is calculated by the value of questions #14-20 with a maximum value of 28 points, and this indicates a distinctly morning type. The minimum number of points is 7 and indicates a distinctly evening type. Circadian typology is divided into 4 groups according to the values of the M-E score: 7-11 points strongly evening type, 12-17 points tending towards the evening type, 18-22 points tending towards the morning type and 23-28 points strongly morning type. The M-Z score is calculated by the value of questions #34-37 with a maximum value of 16 points, and this indicates a high level of mental health. Mental health is divided according to the values M-Z, the score is divided into 4 groups: 4-6 points low level of mental health, 7-9 points poor mental health, 10-12 points good level of mental health and 13-16 points excellent level of mental health.
- **Pittsburgh Sleep Quality Index (PSQI)** (Buysse, Reynolds, Monk, Berman, Kupfer, 1989). PSQI is a standardized test in the form of a questionnaire that monitors the overall level of sleep quality and life satisfaction of the subjects, as insomnia often

leads directly to its drastic deterioration. It focuses on the assessment of sleep in seven components: 1. sleep latency, 2. sleep duration, 3. usual sleep efficiency, 4. sleep disorders, 5. sleep quality, 6. use of sleep medication, 7. dysfunction caused by sleepiness. The questionnaire consists of 9 questions focused on sleep patterns during the past month.

- **Battery of balance tests** (Wood, 2008; Kulma, 2021):

R1 - Balance board test (Wood, 2008), endurance on the balance board in the speed skating squat, speed skaters had their hands on their backs. Time was measured in seconds, and the test was terminated by an error in the form of the board touching the ground. According to Wood (2008), the evaluation of this test is 1 point for every 0.3s, the maximum is 100 points for 30s. The better the result, the better the balance skills.

R2 - Bass test (Wood 2008), during this test the subject jumps on one leg to drawn marks that are precisely determined and 76.2 cm apart. The test taker must last 5 seconds without touching the ground with the other foot, then jump to the next mark. The test is terminated by loss of balance by touching the ground with the other foot, or by an imprecise jump to a mark that the foot does not completely cover. The evaluation of the test according to Wood (2008) is: subject jumped without error all 10 drawn marks - passed, subject did not jump all 10 drawn marks, or made a mistake - failed.

R3 - Endurance in driving on one leg, in sliding skates on ice (Kulma 2021). The test was performed on both legs. In this test, the monitored speed skaters were tasked with picking up speed on their skates and from a designated mark to perform a one-leg ride down the slide "in a speed skating position" in order to ride as many seconds as possible. The test was terminated by touching the non-tested leg to the ice. The evaluation of this test was set at 1 point for 0.6s and 100 points for 60s. The better the result, the better the balance skills on the speed

skates. Each speed skater has his own speed skates, which are specially designed and constructed for his body type, so as to minimize the difference in the friction surface of the skates on the ice and thus minimize the difference in speed between individual speed skaters depending on the body type, body weight, body height, or gender.

Statistics

The measured data were processed using statistical methods, especially descriptive statistics using numerical and graphic methods. Furthermore, absolute and relative frequencies were used to express the results. The Microsoft Excel 2016 editor was used, which has a library of statistical, mathematical and graphic functions for creating graphs, tables and basic descriptive methods such as average, minimum, maximum, etc.

4 RESULTS AND DISCUSSION

4.1 Results of PSQI

From the analysis of the PSQI questionnaire data, it follows that the monitored women from the group of speed skaters had an average point score of 4.8 points during the measured period. Which is below or equal to the threshold of 5 points, which means a good quality of sleep. Of the 12 monitored women, 4 women had a value above 5 points, which indicates a deteriorated quality of sleep. The men had an average measured PSQI value of 3.175, which indicates a good quality of sleep, of the 8 monitored men, 2 men had a worsened quality of sleep above the threshold of 5 points. In the comparison of the monitored group of speed skaters, men performed better with an average value of ≈ 3.18 points, compared to women who had an average value of 4.8 points.

The results also show that women went to bed earlier than men. The difference between the time to go to bed between men and women is 24 minutes in October. November 21 minutes, December 37 minutes, January 18 minutes and February 27 minutes. Here there is an increase in the difference with the largest measured value in December, then the lowest measured difference value in January and again an increase in the measured values in February.

These measured results do not correspond to the study by Buysse, Seteia, Krystal, Neubauer, Heald (2017), when the authors tested the quality of sleep, using the PSQI questionnaire, of adolescents at American universities with results of impaired sleep quality, mainly in men. According to authors Ledele (2018), Henriksen, Schinke, Moesch, McCann, Parham, Larsen, & Terry (2020), sleep problems are common among teenagers, mainly problems with falling asleep at late hours, or frequent awakenings from sleep.

Table 1 Comparing men and women in the M-E score

M-E Type	Females	Males
Morning type	3	0
Tendency towards morning type	3	2
Tendency towards the evening type	3	5
Evening type	3	1

The largest representation of 40% is speed skaters with a tendency to gravitate towards the evening type, as the second group are speed skaters with a 25% tendency of the evening type. A little less 20% are represented by speed skaters as a distinctly early morning type. The smallest group of 15% are speed skaters as a distinctly early morning type.

The analyzed results of the circadian typology of monitored speed skaters comparing men and women show that more often women have a higher M-E score than men, and thus VP 1: Monitored men achieve a lower M-E score than women, is confirmed.

The analyzed results correspond to the current trend of the postmodern era (the so-called 24-hour society), that especially men in adolescence sleep less, go to bed longer and fall asleep more difficult, as also confirmed by studies by the authors Harada, Krejčí, Tilinger, Vacek, Wakamura, Kawada, Takeuchi (2016) and Harada, Wada, Tsuji, Krejci, Kawada, Noji, Nakade, Takeuchi (2016). According to Krejčí (2020), Mandelbaum, Harada,

4.2 Results of life rhythms and sleep patterns

To the monitored speed skaters were given a questionnaire on life rhythms and sleep patterns, from which points were added to determine circadian typology (M-E) using questions no. 14-20. Using questions 34-37, points were added up to determine a mental health score (M-H).

Takeuchi, Tsuji, Krejčí (2017) there is a positive influence between circadian typology and mental toughness. An athlete with a low level of mental health usually comes out as a distinctly evening type in the evaluation of the M-E score. A low level of mental health characterizes an athlete who tends to gravitate towards the evening type. A good level together with an excellent level of mental health represent rather or significantly morning types of people who are active mainly in the morning hours and are psychologically balanced.

4.3 Results of balance tests

In the battery of tests for measuring the balance abilities of the monitored speed skaters, the static measurement test, the balance board desk test, the dynamic measurement bass test, and the balance measurement in the slide, the balance test when riding on speed skates on one leg, were used.

Table 2 Overall results of the balance test battery (n=20, 8 men, 12 women)

Categories	Balance board desk	Bass test	Slide		Average
			left leg	right leg	
Females	86,02%	85,00%	92,42%	91,02%	88,62%
Males	85,05%	51,20%	88,03%	88,48%	78,19%
Representative	96,17%	100,00%	103,43%	102,25%	100,46%
National level	69,82%	12,00%	71,52%	71,63%	56,24%
Seniors	95,28%	100,00%	103,08%	102,12%	100,12%
Juniors	75,98%	32,00%	78,27%	77,90%	66,04%

From Table 2, it can be seen, comparing men and women that women were overall better in balance tests with 88.62% than men with 78.19%, by 10.43%. In the Balance board desk test, there was a minimal difference (0.97%) in percentage success between women 86.02% and men 85.05%. In the balance test, the skate slide test, women had a 92.42% success rate on their left leg and 91.02% success rate on their right leg compared to men who had 88.03% success rate on their left leg and 88.48% success rate on their right leg. As a result, women were better in the slide test on the left foot by 4.39% and on the right foot by 2.54% than men. In the Bass test, women had a success rate of 85%, while men had 51.20%. From which it follows that women were better in the Bass test by 32.80% than men. This significant difference confirms VP 2: Monitored women achieve better results in balance measurement in the Bass test.

In the comparison of performance groups of monitored speed skaters, the representative group with 100.46% was better in the battery of balance measurements by 44.22% than the performance group with 56.24%. In the Balance board desk test, the group of representatives had a success rate of 96.17% and was 26.35% better than the group of performance speed skaters with 69.82%. In the Bass test, the group of representatives had a success rate of 100%, which was 88% better than the group of performance speed skaters with a success rate of 12%. In the balance measurement of the one-leg slide test, the representative group had a result on the left leg of 103.43% and on

the right leg 102.25%, compared to the performance group, which had a result on the left leg of 71.52% and on the right leg of 71.63%. The representative group was better on the left leg by 31.91% and by 30.62% on the right leg.

In the correlation of the measured M-E score, where women had a higher M-E score than men, it was shown in agreement with Littlehalse (2016) and in a battery of balance measurement tests, where women were better in all balance tests than men. Although all tested speed skaters write with their right hand, one would expect that the right leg would be the dominant one, it turned out that in most cases of measurement they performed better on the left leg. This may be due to the fact that speed skating is a sport where competitors orient themselves to the left and all turns on the oval are skated to the left. This places greater demands on the left side of the speed skater's body. Every speed skater has encountered the problem that the muscles on the left side of the body are more developed than those on the right side of the body. This fact could result in speed skaters performing better when testing the left leg.

In the diagnostic measurement, experience with balance in an older group of speed skaters, or a group of representatives, was also reflected, which is why the results between a group of older and younger speed skaters, or a group of representatives and a group of performance speed skaters, are so different.

5 CONCLUSIONS

The following hypotheses were verified within the study:

H1: Monitored men achieve a lower M-E score than women. It was verified.

H2: Monitored women achieve better results in the Bass test. It was verified.

Men's mental health scores have been shown to be related to their circadian typology. Only 12.5% of the monitored male speed skaters tended to be a significantly early morning type. Circadian typology was shown in correlation to the results of balance tests, where women were better in all tests than men. In the Bass test, women were 32.8% better than men.

On the basis of the interpreted results and the discussion, the following recommendations can be given for the practice of speed skating coaches: To have an educational effect, especially on young male speed skaters, so that they are motivated and consistently observe a regular circadian regime, i.e. to go to bed earlier (no later than 10 p.m.) and get up in the morning around 7 a.m. and to have regular balanced breakfasts followed by daylight hours for proper serotonin production. The functional balance abilities of speed skaters can be supported by a correctly set circadian regime, and overall their performance in speed skating can thus be favorably influenced.

Acknowledgement

The publication of the presented study was supported by the PALESTRA Foundation – GAPA, ID W/VSP/161/I “Basic research on circadian determinants of lifestyle and performance of Japanese and Czech athletes and non-athletes” “

6 REFERENCES

- Biggins, M., Cahalan, R., Comyns, T., Purtill, H., O’Sullivan, K. (2018). Poor sleep is related to lower general health, increased stress and increased confusion in elite Gaelic athletes [online]. *The Physician and Sportsmedicine*, 46(1), 14–20. doi:10.1080/00913847.2018.1416258.
- Buysse, DJ., Reynolds, CF., Monk, TH., Berman, SR., Kupfer, DJ. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28, 2, 193–213. Doi: 10.1016/0165-1781(89)90047-4.
- Buysse, DJ., Sateia, M., Krystal, AD., Neubauer, DN., Heald, JL. (2017). Clinical Practice Guideline for the Pharmacologic Treatment of Chronic Insomnia in Adults: An American Academy of Sleep Medicine Clinical Practice Guideline. *Journal of Clinical Sleep Medicine*, 13(2):307-349. Doi: 10.5664/jcsm.6470.
- Cao, M., Zhu, Y., Sun, F. Jing, J. (2019). Short sleep duration is associated with specific food intake increase among school-aged children in China: a national cross-sectional study. *BMC Public Health* 19, 558 <https://doi.org/10.1186/s12889-019-6739-8>.
- Harada, T., Krejčí, M., Wakamura, T., Kawada, T., Takeuchi, H. (2016). Education to promote healthy sleep habits in athletes. In Krejčí, M., Tilinger, P., Vacek, L. (Eds.) *Education to Wellness – Education through Wellness*. Prague: College of Physical Education and Sport PALESTRA, Ltd. pp. 76 – 104. ISBN 978-80-87723-23-4.
- Harada, T., Wada, K., Tsuji, F., Krejci, M., Kawada, T., Noji, T., Nakade, M. & Takeuchi, H. (2016). Intervention study using a leaflet entitled “three benefits of “go to bed early! get up early! and intake nutritionally rich breakfast!” a message for athletes’ to improve the soccer performance of university soccer team. *Sleep and Biological Rhythms* 14, 65–74 <https://doi.org/10.1007/s41105-015-0035-5>
- Henriksen, K., Schinke, R., Moesch, K., McCann, S., Parham, W. D., Larsen, C. H., & Terry, P. (2020). Consensus statement on improving the mental health of high performance athletes. *International Journal of Sport and Exercise Psychology*, 18(5), 553-560.
- Herawati, K., Gayatri, D. (2019). The correlation between sleep quality and levels of stress among students in Universitas Indone-sia. *Enfermería Clínica* [online]. The Second

- International Nursing Scholar Congress of Faculty of Nursing, Universitas Indonesia, [cit. 2022-01-19]. 357–361.
Doi: 10.1016/j.en-fcli.2019.04.044
- Kassin, S. (2007). *Psychologie*. Praha: Computer Press, 2007.
- Kellmann, M., Beckmann, J. (2018). *Sport, Recovery, and Performance*. Milton park: Taylor and Francis Ltd.
- Krejčí, M., Psotta, R., Hill, M., Kajzar, J., Jandová, D., Hošek, V. (2020). A short-term yoga-based intervention improves balance control, body composition, and some aspects of mental health in the elderly men. *Acta Gymnica*, 50, (1) 16–27. doi: 10.5507/ag.2020.004.
- Krejčí, M. *Zdravotní prevence a wellness ve 21. století: studijní opora k distančnímu vzdělávání*. Praha: Vysoká škola tělesné výchovy a sportu PALESTRA, spol. s.r.o., 2020.
- Kulma, P. (2022). *Výzkum kvality spánku a spánkových preferencí u skupiny rychlobruslařů vzhledem k funkční schopnosti řízení rovnováhy*. Praha: Vysoká škola tělesné výchovy a sportu Palestra.
- Lederle, K. (2018). *Spánkem ke zdraví*. Olomouc.
- Littlehales, N. (2016). *Spánek*. Praha: Albatros media.
- Mandelbaum, M., Harada, T., Takeuchi, H., Tsuji, F., Krejčí, M. (2017). Selected circadian determinants of performance in super league floorball players. *Acta Salus Vitae*, 5(2), 46–60. Retrieved from <http://odborne.casopisy.palestra.cz/index.php/actasalusvitae/article/view/135>
- Měkota, K., Novosad, J. *Motorické schopnosti*. Olomouc: Univerzita Palackého v Olomouci, 2005.
- Orie, J., Hofman, N., De Konig, J. (2014). Thirty-eight years of training distribution in Olympic speed skaters [online]. *International Journal of Sports Physiology and Performance*, 9, 93-9. ISSN 1555-0273. Dostupné z: Doi:10.1123/IJSPP.2013-0427.
- Šmotek, M., Kopřivová, J., Soš, P. (2016). Vliv modrého světla na cirkadiánní systém, spánek a kognitivní výkonnost. *Psychiatrie*, 20(1), 29-34.
- Thirion, M., Challamel, MJ. (2013) *Spánek, sen a dítě*. Praha: Argo.
- Wood, R. (2008) Balance Fitness Tests. *Sports Website.*, Available on: <https://www.topendsports.com/testing/balance.htm>
- Zhao, J., Tian, Y., Nie, J., Xu, J., Liu, D. (2012). Red light and the sleep quality and endurance performance of Chinese female basketball players. *Journal of Athletic Training* 47(6):673-8. Doi: 10.4085/1062-6050-47.6.08.

7 CONTACTS

Pavel Kulma, BA.

Czech Association of Speed Skating, Czech Republic

E-mail: kulma.pavel@gmail.com