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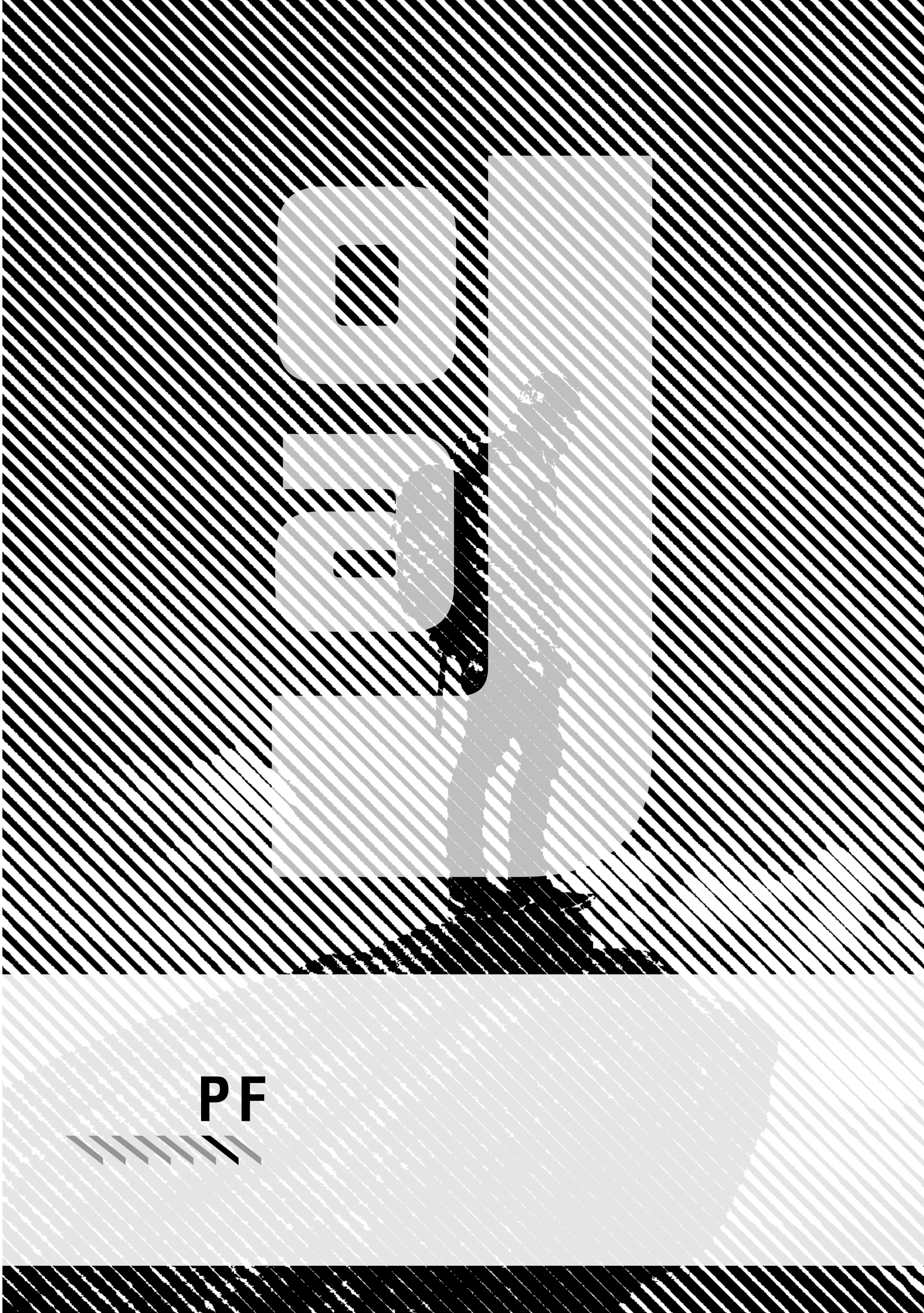
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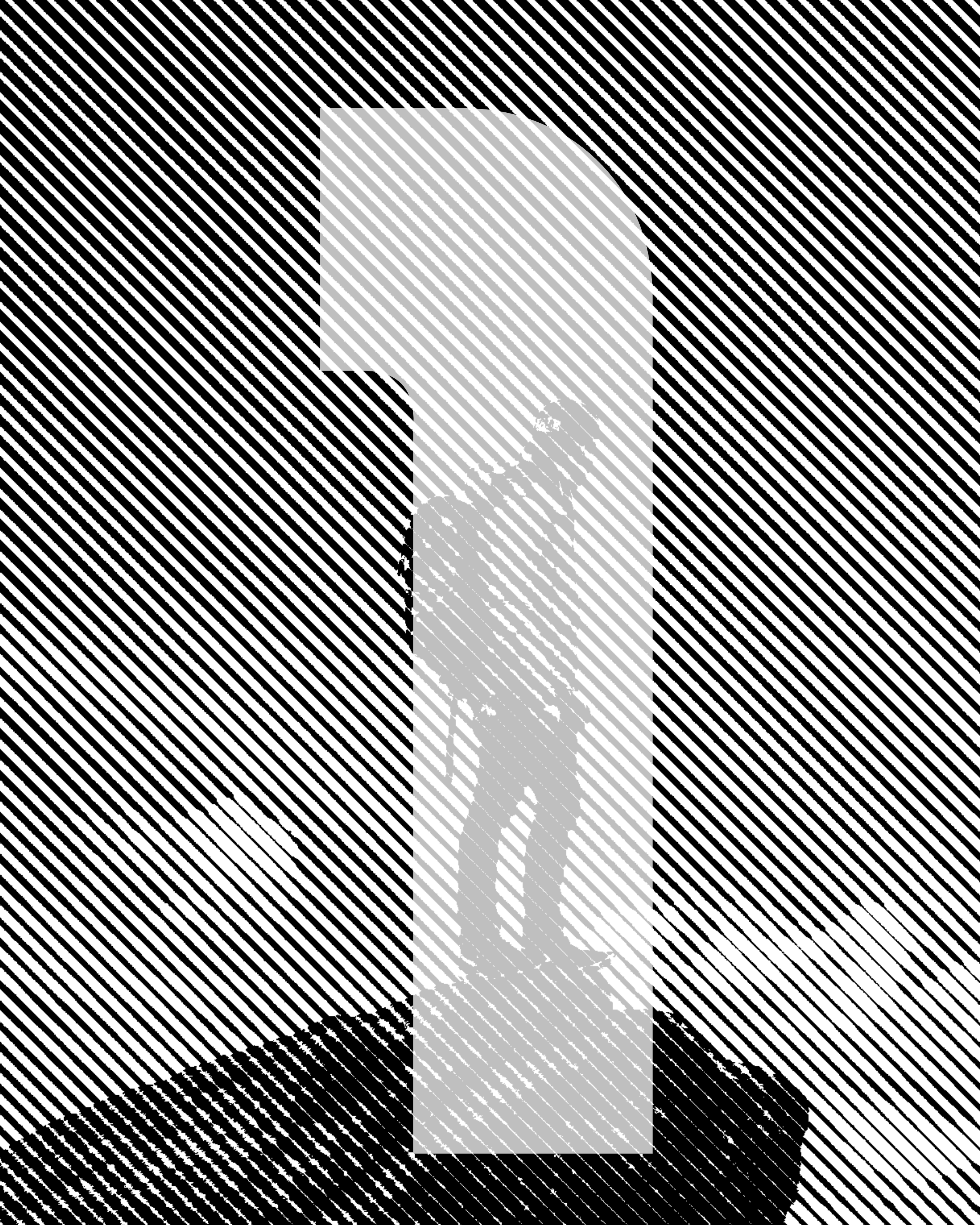


RESEARCH PAPERS

Outdoor activities and their impact on the lifestyle of adolescents

Stanislava Straňavská, Karol Görner
Faculty of Arts, Department of Physical Education and Sport, Matej Bel University in Banská Bystrica

Abstract

Outdoor activities are an ideal and attractive combination of physical activity and exercise in a natural environment. They include sport and physical activities performed outside that are not age-restricted (for children, adults and the elderly), with hiking being one of the most common outdoor activities. Physical activities are related to the quality of life, lifestyle and the state of health in specific ways. Grahn and Stigsdotter (2003) claim, that outdoor activities can improve health regardless of the age and sex of the participants and that they also provide prevention from stress-related diseases. The term "lifestyle" is nowadays used with many different attributes such as healthy lifestyle, active lifestyle or consumer lifestyle. These types of lifestyles are directly related to the behaviour of individuals in both their personal and working life. This paper is focused on the way in which outdoor activities can influence, or rather alter the lifestyle of adolescents. Here, schools play an important role. They offer space for the realization of outdoor activities, which can have positive impact on the human body. Authors such as Bendíková (2012), Oborný & Kotyra (2008), Görner & Kompán (2008), Michal (2010), Straňavská (2015) agree with this hypothesis.

The results of our research show differences in participation in free-time outdoor activities in relation to gender, where we have found that boys rate the quality of their lifestyle higher than girls. Some relationships between the lifestyle quality of students and specific variables (gender, place of residence and rate of participation in outdoor activities) are consequently observed. Participation in outdoor activities significantly influences the self-evaluation process of lifestyle quality and there is also a connection between participation in outdoor activities and the location of students, where we have found statistically significant differences at the level of significance $p < .05$. We consider these findings to be of great importance.

Key words

Outdoor activities, lifestyle, adolescents, physical and sport activity.

Souhrn

Věnování se pravidelné pohybové aktivitě označujeme za nejdůležitější při utváření zdravého životního stylu. Autoři se v příspěvku zabývají vlivem outdoorových aktivit na životní styl dospívajících a prezentují možnosti využití volného času adolescentů, čímž zdůrazňuje význam sportovních aktivit nabízených školou, kterou žáci navštěvují. Nejdůležitější roli v tomto případě hrají školy, které nabízejí svým žákům mimo vyučovacího procesu zapojit se do outdoorových aktivit. S pojmem outdoorové aktivity je úzce spjat pojem pobytová aktivita, což se ukazuje jako velmi pozitivně ovlivňující možnost k tomu, aby žáci věnovali svůj volný čas aktivnímu pohybu v přírodě, který má pozitivní účinek na jejich organismus.

Ve výsledcích poukazujeme na rozdíly při provádění outdoorových aktivit ve volném čase v závislosti na pohlaví a následně uvádíme souvislosti mezi úrovní životního stylu žáků a proměnnými (pohlavím, bydlištěm a prováděním outdoorové aktivity). Za významné považujeme zjištění, že provádění outdoorové aktivity má značný vliv při vlastním posouzení aktuálního životního stylu a také, že existuje souvislost mezi prováděním outdoorové aktivity a bydlištěm žáka, kde se nám prokázali statistický významné rozdíly na hladině významnosti $p <0,05$.

Klíčová slova

Outdoorové aktivity, životní styl, adolescenti, pohybová a sportovní aktivita

Introduction

This of course trans The most important factor influencing our possibilities to lead an active life is the general state of our health – shaped by every single step of our everyday life. Nowadays, there are many factors that have a negative impact on our mental and physical health and that is why we have to find a way of coping with them (Rošková & Hudák, 2015). The term "healthy lifestyle" is more and more widely used and such a way of life is influenced by a great number of factors not just by the environment in which we live, but also by eating habits, cultural background, social background and last but not the least – by physical activity, which is one of the most important factors and part and parcel of our lifestyle that hugely influence both mental and physical health as well as the self-evaluation process of our quality of life (Liba & Uherová, 2003).

In our hurried times people tend to neglect physical activities affecting their general state of health. Several pieces of research concerning physical activities – ina ropriate eating habits, water intake and drug addictions in all age groups – highlight that the current status is hugely unsatisfying (Adamčák & Nemec, 2011; Görner, 2014; Chovanová, 2005; Pávková et al. 2008). Students sit and play videogames, spend time with mobile phones and smartphones and physical or sporting activities are becoming a marginal phenomenon. Modern conveniences – such as the internet – mean that students do not have to visit libraries or other educational institutions as they can find almost all information online. Our contemporary sedentary lifestyle and ina ropriate eating habits are the cause of various metabolic disorders in young people. As a result, more and more young people have obesity-related health issues and suffer from various diseases. Therefore, we have to try to demonstrate the negative outcome of such types of lifestyle by the means of various public information campaigns and last but not the least by the use of social networks. People living in the countryside tend to be much more physically active in their free-time when compared to those living in urban environment (Humpel et al 2002; Killingsworth, 2003; Owen et al., 2004, Sallis et al 2000).

Within the campaign for the healthy lifestyle of young people, physical activities performed in the free-time of elementary and high school students should be emphasized. Such physical activities should be performed outside of school hours – it has to be stressed, this is not within PE classes. In this way, the performance of students is not evaluated, which could result in the increased interests of students in such activities. Outside of PE classes, many physical activities could be undertaken. Such activities need to be popular among students – e.g. hiking, inline skating, cycling, pétanque, Nordic walking, etc. – and also would prove beneficial for their physical condition and state of health as all similar activities have a positive impact on the human organism. Free-time physical activities are suitable for everyone regardless of their age and skills. Outdoor physical activities especially significantly improve our physical and mental conditions. Attractive and well-organized outdoor activities could improve the perspective of young people in regard to physical activities and they can also improve their creativity.

Aim

The aim of this research, conducted within the KEGA project No. 021UMB-4/2015, was to identify the outdoor activities in which adolescents participated most and to define the potential impacts on their lifestyle.

Methodology

Research was conducted in the academic year 2015/2016. The research group consisted of second-year, third-year and fourth-year high school students studying at schools in the town of Humenné. High schools were chosen by stratified random sampling. The total number of respondents involved in our research was 630 – 354 girls and 276 boys. Questionnaires were used as the main method for the data collection. Questionnaires were given to respondents either personally or with the aid of their teachers; all teachers were acquainted with the research and all the questions were fully explained to them. All questionnaires were filled-out and returned. Acquired results were processed and assessed by qualitative research methods. $\chi 2$ test – nonparametric test was used to assess the independence between quantitative variables. The $\chi 2$ test of independence was a lied when testing dependence between the groups of two variables – current lifestyle and gender, place of residence, education of parents and participation in outdoor activities. We determined the statistical significance on the level of significance $p < 0,05$.

Description of statistical significance:

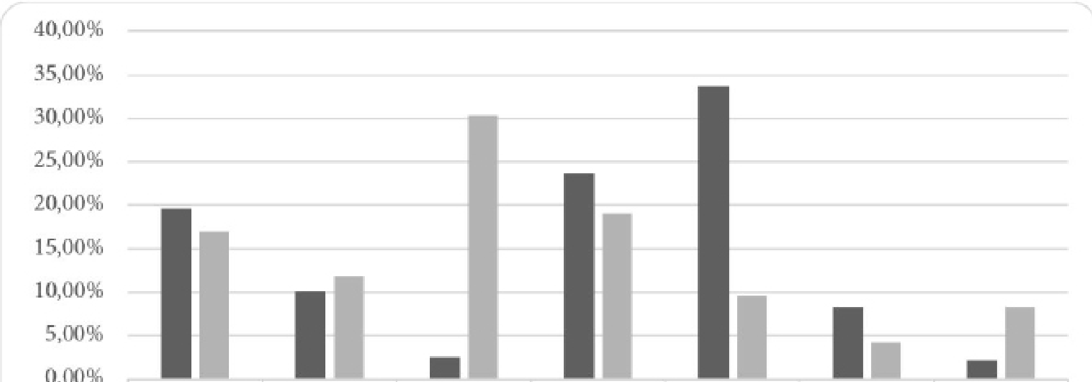
- statistical significance on the level of significance $p < 0,05$
- si – statistically insignificant difference.

Results and Discussion

Any type of free-time physical activity has a positive impact on the human body and on the general state of an individual's health. Similiar outcomes were stated in the researches of Jedlička (2009) and Straňavská & Görner (2015), who claim that outdoor activities are an ideal way to spend one's free-time.

In the aforementioned questionnaire we wanted to assess whether the students participated in outdoor activities in their free-time and which outdoor activities were the most common.

Figure 1 . Free-time outdoor activities

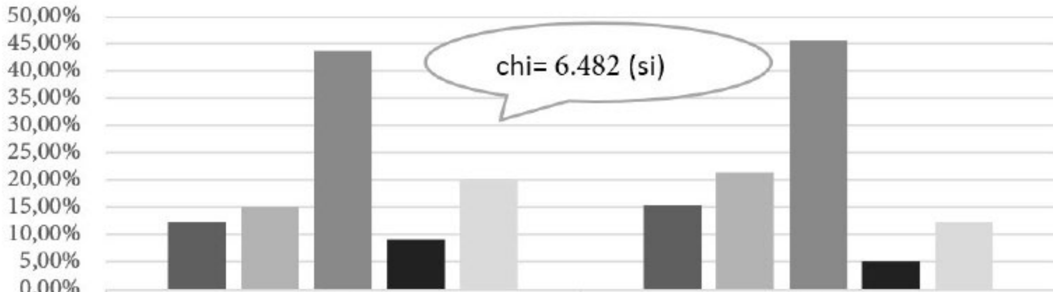


	hiking	running	inline skating	skiing	cycling	others	none
boys	19,66%	10,08%	2,45%	23,64%	33,69%	8,30%	2,18%
girls	16,94%	11,78%	30,28%	19,04%	9,54%	4,15%	8,27%

In the course of this analysis we discovered that boys prefer cycling and girls inline skating in their free-time (fig No. 1). After a more detailed analysis we came to the conclusion that the second most common and popular outdoor activity both among boys and girls is skiing. Category "others" were stated by 8.30% of boys – the most represented activities being geocaching, pétanque and baseball. 4.15% of girls stated in category "other" activities such as geocaching – similar to boys – followed by Nordic walking. As many as 8.27% of girls stated that they do not participate in any sort of outdoor activity which is a negative phenomenon. Similar results – boys expressing greater interest in free-time outdoor activities – were also stated by Bartík (2009), Michal (2010), Šimonek et al. (2010) and others. In their studies, Nielsen and Hansen (2007) came to the conclusion that almost 95% of population living in America do not participate in any free-time outdoor activity, or rather spend their free-time indoors mainly by watching television.

Several researches – concerning the issues of lifestyle in relation to outdoor activities – came to the conclusion that boys live healthier lives than girls (Broďáni & Kamas, 2011; Michal & Nevolná, 2012 and others). As we can see in the fig No. 2, even in our research there are specific differences in the lifestyle quality between boys and girls, but the results of $\chi 2$ test of independence shows us that between boys and girls there are no statistically significant differences at the level of significance $p < .05$.

Figure 2. Dependence between lifestyle and gender of students



	girls	boys
very good	12,32%	15,43%
good	15,07%	21,36%
average	43,67%	45,71%
bad	9,07%	5,08%
very bad	19,87%	12,42%

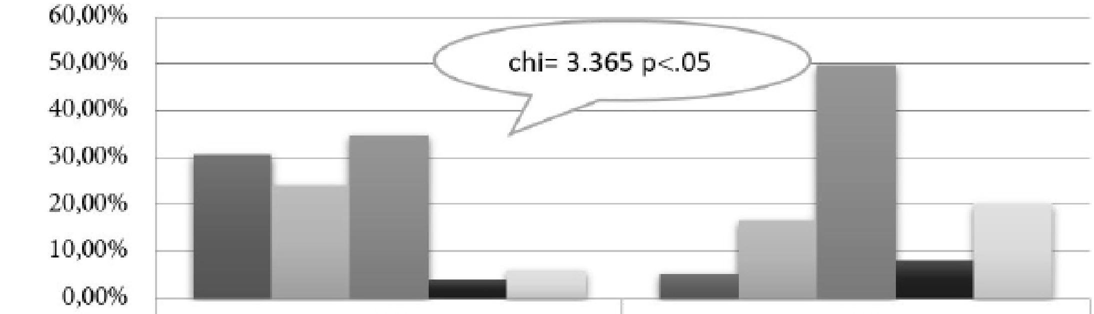
The research also focuses on the determination of differences in lifestyle quality in relation to the place of residence of students. As we can see in figure No. 2, there are specific differences between students living in the countryside and in the towns, but the results of $\chi 2$ test of independence are not statistically significant at the level of significance $p < .05$ and therefore it can be concluded, that there is no significant dependence between lifestyle and the place of residence.

Figure 3. Interrelations between lifestyle and place of residence of students

	countryside	towns
very good	16,64%	15,21%
good	20,33%	18,63%
average	41,75%	43,11%
bad	7,91%	7,54%
very bad	13,37%	15,51%

Dependence between current lifestyle and outdoor activities is shown in figure No. 4. In the figure we can see differences in the lifestyle of students engaging and not engaging in any outdoor activity. The Chi-Quadrat-Test shows us statistically significant differences at the level of significance $p < .05$ between the lifestyle of students participating in an outdoor activity and lifestyle of students who do not participate in any outdoor activity. In the figure we can see that students participating in an outdoor activity rate their lifestyle quality mainly on the scale *average – very good*, whereas students who do not participate in any outdoor activity rate their lifestyle quality on the scale from *average* down to *very bad*.

Figure 4. Dependence between lifestyle and participation in outdoor activity

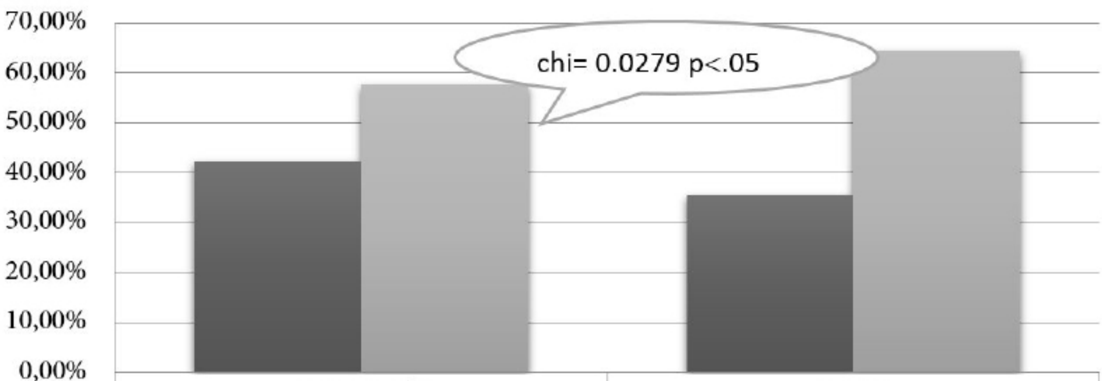


	yes	no
very good	30,77%	5,24%
good	24,26%	16,73%
average	34,97%	49,75%
bad	3,93%	8,14%
very bad	6,07%	20,14%

Chart legend: x-axis: participating in and not participating in an outdoor activity, y-axis: lifestyle category expressed in %

In figure No. 5 it is evident, that there is a difference in participation in outdoor activities between students living in towns and students living in the countryside, while the p-value of Chi-Quadrate-Test of independence (p = .0279) shows us a statistically significant difference at the level of significance p < .05. Students living in the countryside tend to participate in outdoor activities more often – one possible reason being their stronger connection to nature than students living in towns. From the aforementioned it can be seen that students living in the countryside tend to spend their free-time more actively than students living in towns. The dominant result – no participation in any outdoor activity by 57.63% of students living in the countryside and 64.39% of students living in towns – is another negative phenomenon.

Figure 5. Dependence between participation in outdoor activity and place of residence of adolescents



	countryside	towns
yes	42,37%	35,61%
no	57,63%	64,39%

Chart legend: x-axis: place of residence, y-axis: participating in, or indeed not participating in an outdoor activity

Conclusion

The paper researches participation in free-time outdoor activities and studies how outdoor activities influence the lifestyle quality of adolescents. General conclusions can be drawn –every physical activity has a positive impact on one's lifestyle. We agree with the findings of Dobrý (2006), who stated, that there is a dependence between participation in physical activities and the health state of individuals. In our research we came to the conclusion, that students participating in outdoor activities tend to rate their lifestyle quality higher than students who do not participate in any significant amount of outdoor activity. Participation in outdoor activities significantly influences the self-evaluation process of lifestyle quality and there is also a dependence between participation in outdoor activity and the place of residence of students, in which we have found statistically significant differences at the level of significance $p < 0.05$. Schools have a considerable impact on the process of formation of positive habits in regard to physical activities and therefore they should offer wider possibilities for spending free-time in the form of a range of physical activities.

References

1. Adamčák, Š., & Nemec, M. (2011). Vzťah žiakov 2. stupňa základných škôl k športu, telesnej výchove a obľúbenosť vybraných pohybových aktivít na hodinách telesnej a športovej výchovy. *Perspectives of Physical Training Process at Schools*. Innsbruck – Austria: SAS School, 21-30.
2. Bartík, P. (2009). Postoje žiakov základných škôl k telesnej výchove a športu a úroveň ich teoretických vedomostí z telesnej výchovy v intenciách vzdelávacieho štandardu. *Tel. Vých. Šport, 19* (4), 4-6.
3. Bendíková, E. (2012). *Kapitoly z didaktiky školskej telesnej a športovej výchovy.* Banská Bystrica: UMB.
4. Broďáni, J., & Kamas, T. (2011). Pohybové aktivity u 9-10 ročných žiakov v regióne Spiš. In: Anonymus. Ošetrovateľstvo – pohyb – zdravie. *Zborník vedeckých prác Trenčianska univerzita Alexandra Dubčeka Fakulta zdravotníctva.* Trenčín: TnUAD, 238-224.
5. Dobrý, L. (2006). Úvod do problematiky vztahů pohybových aktivit a zdraví. *Tělesná výchova a sport mládeže, 72*(3), 4-13.
6. Görner, K. (2014). *Miesto turistiky a športovo pohybových aktivít v prírode v spôsobe života vysokoškolskej populácie stredoslovenského regiónu.* Banská Bystrica: UMB.
7. Görner, K., & Kompán, J. (2008). *Miesto turistiky a pohybových aktivít v prírode v spôsobe života mladej populácie veku 12 – 15 rokov na začiatku nového storočia.* Banská Bystrica: UMB.
8. Grahn, P., & Stigsdotter, U. (2003). Landscape Planning and Stress. *Urban Forestry and Urban Greening, 2*(2), 1-18.
9. Humpel, N. et al. (2002). Environmental Factors Associated with Adults' Participation in Physical Activity. *American Journal of Preventive Medicine, 22*(4), 188–99.
10. Chovanová, E. (2005). Research on motorocity of children of the yonger schoolage. *Acta Universitatis Matthiae Belii, Physical education and sport, 6* (6), 74-82.
11. Jedlička, J. (2009). *Zdravý životný štýl.* Nitra: Slovenská poľnohospodárka univerzita.
12. Kalinková, M. (2011). Turistika vo voľnom čase detí a mládeže. In Anonymus (Eds.). *Šport a zdravie - zborník vedeckých prác.* Nitra: UKF, 137-144.
13. Kačmariková, M., & Izakovičová, E. (2011). Životný štýl študentov verejného zdravotníctva FZ a SP v Trnave. In Anonymus (Eds.). *Ošetrovateľstvo – pohyb – zdravie - zborník vedeckých prác.* Trenčín: TnUAD, 291-298.
14. Killingsworth, R. (2003). Health Promoting Community Design [Special issue]. *American Journal of Health Promotion 18* (4), 111–122.
15. Liba, J., & Uherová, Z. (2003). Zdravotná funkcia školy kontexte pohybovej výchovy mládeže. In Anonymus (Eds.). *Zborník prác z 8. Vedeckej konferencie „Zdravá škola".* Prešov: Metodicko-pedagogické centrum v Prešove, 11-15.
16. Michal, J. (2010). Voľnočasové pohybové aktivity a ich vplyv na zdravotný štýl žiakov základných škôl. *Pohyb a zdravie, 1*(2), 97-108.

17. Michal, J., & Nevolná, T. (2012). Physical activity as an effective means to a healthy lifestyle. *Telesná výchova a šport, 4* (1), 103-115.
18. Nielsen, T., & Hansen, K. (2007). Do Green Areas Affect Health? *Health and Place, 13*(4), 839–850.
19. Oborný, J., & Kotyra, J. (2008). Voľný čas a šport v životnom štýle stredoškolákov. In Anonymus (Eds.). *Sport a kvalita života 2008 - Medzinárodná vedecká konferencia.* Brno: Masarykova Univerzita. 107-116.
20. Owen, N. et al. (2004). Understanding Environmental Influences on Walking: Review and Research Agenda. *American Journal of Preventive Medicine, 27*(1), 67–76.
21. Pávková, J. et al. (2008). Podíl škol a školských zařízení na výchově dětí ve volném čase. In Anonymus (Eds.). *Pedagogika voľného času – teória a prax - zborník z vedeckej konferencie s medzinárodnou účasťou.* Trnava: Pedagogická fakulta Trnavskej univerzity, 34-40.
22. Rošková, M., & Hudák, T. (2015). Vplyv fyzickej záťaže na úroveň psychickej a pohybovej výkonnosti. In Anonymus (Eds.). *Optimalizácia zaťaženia v športe.* Banská Bystrica: UMB, 29-42.
23. Sallis, J. et al. (2000). A Review of Correlate of Physical Activity of Children and Adolescents. *Medicine and Science in Sports and Exercise, 32*(2), 963–975.
24. Straňavská, S., & Görner, K. (2015) Športovo-pohybové aktivity v prírode v spôsobe života stredoškolskej mládeže v Humennom. *Telesná výchova a šport v živote človeka, 1*(2), 256-268.
25. Straňavská, S. (2015). *Tourism and physical activities in the countryside in the life style of secondary school students.* Hradec Králové: Gaudeamus.
26. Šimonek, J. et al. (2010). *Outdoor motor activities.* Nitra: UKF.

Author: PaedDr. Stanislava Straňavská
E-mail: stanislava.stranavska@umb.sk

Influence of sport climbing on selected physical abilities and heart rate

Lenka Černá, Patrik Černý, Zuzana Lhotová, Hana Kabešová
Department of Physical Education and Sport, Faculty of Education, University of Jan Evangelista Purkyně in Ústí nad Labem

Abstract
The goal of the research is to find out the influence of 11-week long intervention program of sports climbing on the chosen physical abilities and values of maximal heart rate. The research group was made up by adults (n=22) in age 26,4 years (±9,9). The improvement was proven in tests of upper limbs muscle strength, flexibility and coordination. We did not register significant changes in the values of maximal heart rate while climbing. For the improvement of muscle ability is this intervention sufficient. If the goal of intervention is improvement of climbing performance then the range of the intervention must be bigger.

Key words:
Sports climbing, adults, muscle ability, heart rate

Souhrn
Cílem šetření je zjistit vliv 11týdenního intervenčního programu sportovního lezení na vybrané pohybové schopnosti a hodnoty maximální srdeční frekvence. Výzkumný soubor tvořily dospělé osoby (n=22) ve věku 26,4 let (±9,9). Prokázalo se zlepšení v testech svalové síly horních končetin, flexibility i rovnováhy. V hodnotách maximální srdeční frekvence při lezení jsme statisticky významné změny nezaznamenali. Pro zlepšení svalové zdatnosti se takto pojatá intervence jeví dostačující, pokud by bylo cílem intervence zlepšení lezeckého výkonu, pak by musel být rozsah intervence větší.

Klíčová slova:
Sportovní lezení, dospělí, svalová zdatnost, srdeční frekvence

Introduction

Sports climbing is offset of mountain climbing, which is practised on the rocks or artificial walls. In contrast with original mountain climbing, where the goal was to conquer the peak by any method, for sport climbing is characteristic the effort to conquer as highest difficulty as possible. The difficulty of climber´s performance determines the style of conquering of route and degree of difficulty. Vomáčko et al. (2011) define sport climbing as the direction of climbing, where physical problems predominate over psychic. Elements of danger in sport climbing are reduced by using process protection (Sheel, 2004), which is in the sport routes on rocks prepared by the route maker and in the small artificial walls built in small distances. Routes of sport character are fitted with anchors, fixed rings or fixed pro elements, which in the event of a falling catch the climber. Falls in sport routes are fairly common and mostly safe.

Sport climbing belongs to the activities that need a high level of strength and endurance abilities. The performance in sport climbing is influenced by number of factors, from which the strength of the upper limbs seems to be the most striking (Baláš, Pecha, Martin, & Cochrane, 2012; Došla & Meško, 2015; Vomáčko et al., 2011). It means we can to a large extent influence performance in sport climbing by variables, which can be influenced by training (Mermier, Janot, Parker, & Swan, 2000).

The time of performance for conquering climbing route while climbing artificial walls is in the order of a few minutes. While this time, the heart rate of climber rises together with rising climbing effort and difficulty of the route (Sheel, 2004; Sheel, Seddon, Knight, Mc Kenzie, & Warburton R., 2003). It was documented that the heart rate values by climbers come up to approximately 80 – 90 % of maximal heart rate, which is achieved while running (Billat, Palleja, Charlaix, Rizzardo, & Janel, 1995) or on cycloergometer (Sheel et al., 2003). Changes in values of heart rate documents Cesur et al. (2012), who found decline in values of heart rate by adults in the end of route after 8-week climbing training, compared to the initial values. They rationalize this decline by managing skills and techniques, which has a significant part in energetic output while climbing movement.

There has been published a few studies investigating the influence of short intervention programmes of sports climbing on chosen components of capability. The influencing of chosen components of capability by intervention program of sports climbing by prepubescents was applied in the studies (Baláš, Strejcová, Malý, Malá, & Martin, 2009; Schlegel, Fialová, Ulrichová, & Frainšic, 2012). After 10 weeks of regular climbing the artificial walls in out-of-school interest activities was improved the strength and muscular endurance of the upper limbs by children (Baláš, 2007; Schlegel et al., 2012). Differences appeared also in coordination, significant improvement by children in the Flamingo test (Schlegel et al., 2012). However, Baláš (2007) does not confirm the improvement in coordination. By older age categories has been repeatedly proven improvement of strength abilities. Muehlbauer, Stuerchler, & Granacher (2012) had been observing a significant increase of upper trunk muscles strength and increase of hand force after 8-week training program on artificial wall by adults with sedentary job. Higher hand force maintained also after 8 weeks without training. Intervention program by adolescents in the form of a climbing course had been verifying Heitkamp, Wörner, & Horstmann (2005), who found by post-intervention probands higher strength gains than those in the control group which did not go through intervention. Černá, Černý, & Kabešová (2016) have proven that inclusion of motion program – climbing artificial walls may in relatively short time improve strength abilities of upper limbs by adults.

The aim of our research is to find out influence of 11-week intervention program of sports climbing on selected physical abilities and compare values of maximal heart rate while climbing in the beginning and in the end of intervention.

Methods

The research group was made by adults (n=22, 3 men, 19 women), who went through 11-week course of climbing artificial wall. None of tested people had previous experience with climbing. The course was made up by one lesson per week with a total length of 90 minutes. Each lesson included a warm up in the initial and preparatory part by special climbing exercises low above ground. In the main part, there was individual climbing the routes in pair. Before the beginning of course was made the first measuring (pretest) and after 11 weeks, when had the tested people regularly attended climbing lessons, was measuring repeated (posttest). Following components were measured: hand dynamometry, endurance in pull-up with overhand grip, endurance in hanging position with one hand, standing on one leg with eyes closed, deep bow in sitting position, chest bending in lying on belly position.

Tests were chosen on the basis of study of studies, which are dealing with factors that influence performance in climbing (Baláš et al., 2012; Došla & Meško, 2015; Vomáčko et al., 2011) and influence of climbing on physical abilities (Baláš, 2007; Muehlbauer et al., 2012; Schlegel et al., 2012). Furthermore, we were considering their similarity with climbing performance while choosing tests. Applied tests are described in the following text.

Hand dynamometry

This test measures short-time static-strength ability of hand flexors and fingers and is a part of Eurofittest for adults (18-65) (Havel & Hnízdil, 2009). The maximal strength of hand grip was measured with electronic hand dynamometer Camry, model EH101. Tested person was invited to grip dynamometer with maximal strength of dominant hand. Test was applied in the standing position, in position with arm close to the body. Tested people have available two attempts, the better from attempts was recorded.

Endurance in pull-up with overhand grip

This test measures endurance static-strength ability of arms and shoulder girdle and is a part of test batteries Unifittest (6-60) (Měkota et al., 2002), Fitnessgram (Suchomel, 2003) a Eurofittest (Šimonek, 2012). The time during the test person holds in pull-up with overhand grip on horizontal bar is measured. Tested person was placed into initial position in pull-up with overhand grip with his/her chin over the horizontal bar. The aim was to hold the position for as long time as possible. As soon as chin descended under level of horizontal bar the test was ended. Time was recorded with accuracy of 1 second.

Endurance in hanging position with one hand

The test measures endurance static-strength ability of dominant hand, arm and shoulder girdle. Test was used in intervention studies focused on climbing artificial wall (Baláš, 2007; Schlegel et al., 2012). It is applied due to the similarity with the climbing movement. Tested person performs hanging position with both hands on horizontal bar, then he/she release one hand. The examiner may hold tested person while taking proper position and prevent rotating his/her body. The time of endurance in hanging position with dominant hand is measuring with accuracy of 1 second.

Standing on one leg with eyes closed

In this test was tested static balance ability. The tested person stood up on one leg on a hard mat. With the sole of the second foot he leaned on the knee of the same leg, he laid his hands on his hips and closed eyes. Once he set this basic position, the time had begun to be count. This test has been repeated for three times over and the results of attempts were calculated in the end (Havel & Hnízdil, 2010).

In the test was measured flexibility – suppleness and muscle elasticity in the lumbar spine and hip joint. For the test was necessary bench, desk for placing tape and tape measure. Tested person sat down on hard mat with legs together, stretched his legs so his heels touched the perpendicular wall of the bench, and hands were stretched forward. Tested person began to slowly lean forward and hold on in the utmost position for 2 seconds. On the desk, which was above the bench was placed tape with scale from 0-50 centimetres. The value in the place of foot support was 15 centimetres. Measured values obtained in centimetres are added od subtracted from the foot support. Of total two attempts was counted the better one (Havel & Hnízdil, 2010).

Chest bend

This test measures strength and mobility of trunk extensors and is a part of test battery Fitnessgram Fitnessgram (Šimonek, 2012). Tested person lied on his/her belly, arms held close to the body and pressed from side to thighs. Tested person slowly performed chest bend and eyes were concentrated to the sign on the ground. We measured distance between chin and ground in centimetres. Head was in the extension of trunk and legs stayed on the mat. Maximal value is 30 centimetres, bigger bend is not performed or measured neither.

Measuring of heart rate

While climbing performance, record of heart rate was accomplished by 15 people from the test group. Measuring was performed twice, for the first time in the initial part of lesson and for the second time in the final one. Probands climbed the route in the same profile and in the same difficulty in style toprope, which means that they were belayed from above. Record was performed by Sporttester Polar M400. The record of heart rate was evaluated by web application Polar flow. Observed variable was maximal heart rate.

Statistical analysis

For anthropometric characteristics and describe of results in motoric tests by individual groups divided according to the field of study and gender was used methods of descriptive analysis. Differences in performances in individual tests in pretest and posttest was compared in the Wilcoxon test for comparing paired values. For data processing were used Microsoft Excel and Statistics programmes.

Table 1. Anthropometric characteristics of the observed group

	N	Average	Minimum	Maximum	SD
Age (years)	22	26,4	19,0	50,0	9,9
Weight (kg)	22	62,5	50,0	87,0	9,6
Height (cm)	22	168,5	158,0	185,0	7,5
BMI	22	22,0	17,3	29,4	3,0

Table 2. *Changes of results in motoric tests in pretest and posttest*

Variables	Pretest/posttest	Average	SD	p
Hand dynamometry (N)	Pretest	29,2	5,7	0,0001*
	Posttest	31,9	6,4	
Endurance in pull-up (s)	Pretest	5,2	6	0,0004*
	Posttest	7,1	6	
Endurance in hanging position (s)	Pretest	2,3	2,5	0,0001*
	Posttest	4,2	3,2	
Standing on one leg (s)	Pretest	24,6	13,8	0,0007*
	Posttest	39,6	21,8	
Deep bend (cm)	Pretest	22,9	8,8	0,0001*
	Posttest	25	9,1	
Chest bend (cm)	Pretest	20,4	4,6	0,0001*
	Posttest	24,5	4,5	

Explanatory notes: SD = determinative deviation, p = calculated value of Wilcoxon paired test

** differences are significant jsou významné at the probability level p<0,05*

Results

Average results in motoric tests evince improvement after completing 11-week climbing artificial walls course. Statistic importance of improvement in motoric tests was evaluated by Wilcoxon paired test for dependent variables. Significantly eminent improvement was found in all motoric tests.

Maximal values of heart rate are shown in Table 3. The first measuring was performed in the first climbing lesson, the second one in the last lesson.

Table 3. Values of maximal heart rate

Proband	1.measuring	2.measuring	Difference
1	189	180	-9
2	200	190	-10
3	194	190	-4
4	190	193	3
5	178	179	1

6	165	171	6
7	184	177	-7
8	171	173	2
9	188	181	-7
10	173	181	8
11	161	162	1
12	163	160	-3
13	182	175	-7
14	191	185	-6
15	197	189	-8

Table 4. Comparing of maximal heart rate in pretest and posttest

	N	**T**	**Z**	**p-value**
1. measuring x 2. measuring	15	30,50	1,68	0,09

Difference in maximal heart rate between measuring number 1 in the beginning of intervention program and measuring number 2 in the end of intervention program is not statistically important. Although the decline in maximal heart rate by most of the probands is obvious, these differences are not significant, which confirms the Wilcoxon test result ($p<0,05$).

Discussion

In our study came up to significant improvement in all motoric tests which were used. It can be judged that also short-time intervention program may contribute to increase of adults muscle capability, which is also confirmed by other published studies to this time (Černá et al., 2016; Muehlbauer et al., 2012).

Tested people in our study have significantly improved themselves in the tests referring to the increase of upper limbs strength, represented tests of hand dynamometry, endurance in pull-up with overhand grip and endurance in hanging position with one hand. Increase of grip strength already after 8-week climbing course documents (Muehlbauer et al., 2012). Černá et al. (2016) confirms significant increase in grip strength and in hanging position with one hand. Tested people in our study evince also significant improvement in the balance test. Although the certain connections between climbing and balance ability exist (Vomáčko et al., 2011) we believe that we can not this discovery overestimate. The result may be partly influenced by learning effect which has become evident in the second measuring where probands could apply experience from measuring in pretest. Improvement in the trunk and lower limbs mobility tests is also documented. Whereas improvement in the chest bend test can be explained by increase of the body centre strength in connection with increase of strength while climbing and similar results also evidence previous study Černá et al. (2016), by unsportsmanlike, we explain improvement in the deep bend in sitting position test more likely by the attending in organised warm up in the beginning of every lesson, than by actual effect of climbing.

The difference in maximal heart rate between measuring number one in the beginning of intervention program and measuring number 2 in the end of intervention program is not statistically important. Our findings are different from results found in study Cesur et al. (2012), who declare significant decline of heart rate values in the end of climbing intervention program compared to initial values. Measuring was performed in the peak of the route. Research done so far suggests that heart rate in the route declines with increasing experience of climbers. This is dependent by better economy of more experienced climber´s movement. Janot, Steffen, & Porcari (2000) proved higher heart rate by starting climbers against recreational climbers with higher experience. Also Bertuzzi, Franchini, Kokubun, & Kiss (2007) presents, that better climbing technique and economics of movement by more experienced climbers has influence on physiologic response of organism. We expected that by our group will also become evident improvement in the technique and higher experience in the end of intervention, which will lead to lower values of measured heart rate, which did not happen. The explanation may be that although tested people managed the basic technique of climbing movements, movement in vertical direction is still not natural for them. Intermuscle coordination and muscle tension do not match underwent burdening. Experiences obtained after 11-week intervention are not sufficient for applying the technique by economical way.

Conclusions

Tested people proved increase of performance in the test referring to the improvement of muscle capability in the end of 11-week intervention program. Significant improvement was proven in muscle strength, flexibility and balance tests.

In maximal heart rate values while climbing in the beginning and in the end of intervention program was not proven any significant differences.

For improvement of muscle capability appears this intervention as sufficient. If its aim is to improve climbing performance then the change of length or frequence of lessons is needed.

References

1. Baláš, J. (2007). *Možnost ovlivnění vybraných složek tělesné zdatnosti u dětí mladšího a staršího školního věku v krátkodobých a dlouhodobých programech lezení.* Praha: Karlova Univerzita.
2. Baláš, J., Pecha, O., J. Martin, A., & Cochrane, D. (2012). Hand–arm strength and endurance as predictors of climbing performance. *European Journal of Sport Science, 12*(1), 16–25. http://doi.org/10.1080/17461391.2010.546431
3. Baláš, J., Strejcová, B., Malý, T., Malá, L., & Martin, A. J. (2009). Changes in upper body strength and body composition after 8 weeks indoor climbing in youth. *Isokinetics and Exercise Science, 17*(3), 173–179. http://doi.org/10.3233/IES-2009-0350
4. Bertuzzi, R. C. de M., Franchini, E., Kokubun, E., & Kiss, M. A. P. D. M. (2007). Energy system contributions in indoor rock climbing. *European Journal of Applied Physiology, 101*(3), 293–300. http://doi.org/10.1007/s00421-007-0501-0
5. Billat, V., Palleja, P., Charlaix, T., Rizzardo, P., & Janel, N. (1995). Energy specificity of rock climbing and aerobic capacity in competitive sport rock climbers. *Journal of Sports Medicine and Physical Fitness, 35*(1), 20–24.
6. Cesur, G., Atay, E., Ogut, S., Polat, M., & Ongel, K. (2012). Effect of indoor climbing exercise on plasma oxidative stress, hematologic parameters and heart rate responses in sedentary individuals. *Biomed Res-India, 23*(4), 566–570.
7. Černá L., Černý, P., & Kabešová, H. (2016). Vliv pohybového programu lezení na umělé stěně na rozvoj vybraných silových a koordinačních schopností u dospělých. *Česká Kinantropologie, 20*(1), 52–60.
8. Došla, J., & Meško, J. (2015). Silové schopnosti a jejich vliv na sportovní výkon v lezení. Studia *Sportiva, 8*(1), 45–53.
9. Havel, Z., & Hnízdil, J. (2009). *Rozvoj a diagnostika silových schopností.* Ústí nad Labem: Pedagogická fakulta Unverzity J. E. Purkyně.
10. Havel, Z., & Hnízdil, J. (2010). *Rozvoj a diagnostika koordinačních a pohyblivostních schopností.* Banská Bystrica: Pedagogická fakulta v Banskej Bystrici.

11. Heitkamp, H. C., Wörner, C., & Horstmann, T. (2005). Klettertraining bei Jugendlichen: Erfolge für die wirbelsäulenstabilisierende Muskulatur TT - Sport Climbing with Adolescents: Effect on Spine Stabilising Muscle Strength. *Sportverletz Sportschaden, 19*(1), 28–32. http://doi.org/10.1055/s-2005-857953
12. Janot, J. M., Steffen, J., & Porcari, J. (2000). Heart ratem responses and perceived exertion for beginner and recreational sport climbers during indoor climbing. *Journal of Exercise Physiology Online, 3*(1), 45-48.
13. Měkota, K., Kovář, R., Chytráčková, J., Gajda, V., Kohoutek, M., & Moravec, R. (2002). Unifittest.pdf. Praha: Univerzita Karlova, Fakulta tělesné výchovy a sportu.
14. Mermier, C. M., Janot, J. M., Parker, D. L., & Swan, J. G. (2000). Physiological and anthropometric determinants of sport climbing performance. *British Journal of Sports Medicine, 34*(5), 359–365; discussion 366. http://doi.org/10.1136/bjsm.34.5.359
15. Muehlbauer, T., Stuerchler, M., & Granacher, U. (2012). Effects of climbing on core strength and mobility in adults. *International Journal of Sports Medicine, 33*(6), 445–451. http://doi.org/10.1055/s-0031-1301312
16. Sheel, A. W. (2004). Physiology of sport rock climbing. *British Journal of Sports Medicine, 38*, 355–360. http://doi.org/10.1136/bjsm.2003.008169
17. Sheel, W. A., Seddon, N., Knight, A., Mc Kenzie, D. C., & Warburton R., D. E. (2003). Physiological Responses to Indoor Rock-Climbing and Their Relationship to Maximal Cycle Ergometry. *Medicine & Science in Sports & Exercise, 35*(7), 1225–1231. http://doi.org/10.1249/01.MSS.0000074443.17247.05
18. Schlegel, P., Fialová, L., Ulrichová, T., & Frainšic, M. (2012). Rozvoj vybraných motorických schopností u dětí školního věku prostřednictvím sportovního lezení. *Česká Kinantropologie, 16*(3), 56–62.
19. Suchomel, A. (2003). Současné přístupy k hodnocení tělesné zdatnosti u dětí a mládeže (Fitnessgram). *Česká Kinantropologie, 7*(1), 83–100.
20. Šimonek, J. (2012). *Testy pohybových schopností.* Nitra: Dominant.
21. Vomáčko, L., Baláš, J., & Jindra, M. (2011). Vybrané kondiční testy a jejich vztah k výkonu ve sportovním lezení. *Studia Sportiva, 5*(1), 105–116.

Author: Mgr. Lenka Černá, Ph.D.
E-mail: lenka.cerna@ujep.cz

Rowing stroke on a single scull versus rowing stroke on an ergometer Concept 2 - Preliminary case study

Martina Zbořilová[1], **Jan Sedlák**[2], **Bronislav Kračmar**[1]
[1]*Charles University in Prague, Faculty of Physical Education and Sport*
[2]*Czech Technical University in Prag, Faculty of Electrical Engineering*

Abstract

The results of common studies have shown that rowing ergometers currently used for training and for competeing have a fixed support base contrary to a real rowing boat, what cause differences in muscular coordination. In the Czech Republic, there is a lack of evidence of this issue despite the fact of success achieved by Czech rowers on the world rowing competitions. Objective: The purpose of the present preliminary case study was to determine a specific structure in timing of 16 selected muscles of specifically chosen experienced elite rower, during two movement patterns: rowing on a single scull versus rowing on an ergometer Concept 2. Methods: By surface electromyography (EMG) we recorded muscular activity, synergies and involvement throughout mean cycle of the rowing stroke. Participant of this study, trained athlete, performed three 2 min. trials on an ergometer Concept 2 separated by 3 min. break. After 10 min athlete repeated three times 2min of rowing separated by 3 min break. Results: The mutual correlations of mean EMG curves of all measured muscles showed, that there were not found any differences in inter-locomotive synchronization of measured muscles. Established values of correlation (r) showed higher level of dynamic balance (performance similarity) between both measured activities. But determination of the muscular activity timing, considering onsets and cessations, was in the percentual results explication of the movement cycle inter-locomotive different. Conclusion: Results showed a great similarity in synergies organizing the muscular coordination in between both measured physical activities. But specific structure timing of the movement in measured muscles was inter-locomotive different in the moments of muscular activity onsets during rowing and during ergometer rowing. This is attributed to the specificity of on-water locomotion.

Key words:

Rowing, Concept 2, Electromyography, Biomechanics

Souhrn

Výsledky zahraničních studií ukázaly, že veslařské trenažery, aktuálně používané pro trénink a závodění, mají pevný bod opory, na rozdíl od veslařské lodě, což způsobuje rozdíly ve svalové koordinace. V České republice je nedostatek literatury na toto téma, přestože čeští veslaři dosahují mnoha výsledků. Cílem této studie pilotní případové studie je determinovat a specifikovat strukturu timingu šestnácti vybraných svalů u zkušeného veslaře ve dvou výzkumných situacích – při veslování na skifu a při jízdě na trenažeru Concept 2. Byla použita metoda povrchové polyelektromyografie, která zaznamenává svalovou aktivitu a zapojení během průměrného cyklu veslařského tempa. Účastník této studie absolvoval tři dvouminutové úseky na veslařském trenažeru Concept 2, oddělené pauzou tři minuty. Pak po deseti minutách absolvoval znovu 3x 2min/3min pauza. Vzájemné korelace průměrných EMG obálek všech měřených svalů ukázaly, že nebyly nalezeny žádné rozdíly v interlokomoční synchronizaci změřených svalů. Dosažené hodnoty korelace (r) ukázaly interlokomočně velkou podobnost v synergii vzájemné svalové koordinace u obou měřených výzkumných situací. Avšak determinace svalového timingu, zahrnující počátky a konce svalové aktivity byla *v procentuálním vyjádření u všech měřených svalů v obou výzkumných situací rozdílná. Toto může být způsobeno specifickou lokomocí na vodním povrchu.*

Klíčová slova:
Veslování, Concept 2, electromyografie, biomechanika

Introduction

Rowing is a complex of motor skills. A considerable amount of research has been done on the mechanics and biomechanics of rowing. Because of the demand for all-year training and control tool, manufacturers developed ergometers for indoor training. Kleshnev (2016) observed rowing ergometer as an efficient device to simulate biomechanical and physiological demands of rowing. Including the use of rowing ergometers as a means for indoor training, rowing became a year-round sport. Consequently, modelled rowing on an ergometer Concept 2 (Concept2, Inc., Morrisville, VT, USA) became a matter to compare with the real on-water rowing. For instance, Marcolin, Lentola, Paoli, & Petrone (2015) compared electromyographic results of elite rowers on-water and ergometer tests. Results showed higher muscles activity on the ergometer, but different coordinative patterns comparing these experimental conditions. Anyway, they concluded ergometer as a valid training device. However specific mechanical variances of these two types of physical activity may affect the pattern of muscle recruitment, coordination and adaptation. Rowing as a power-endurance sport recruits approximately 70% of total body mass and muscle coordination is particularly important due to affect rowing performance (Rodriguez, 1990). Rowing on a Concept 2 ergometer constrains motor control patterns and abilities in coordination and adaptation, which are the consequences of mechanical and external factors during rowing (Nevill, Allen, & Ingham, 2011). Different structure of momentum during rowing stroke on an ergometer causes different timing of peak point (Christov, Ivanov, & Christov 1989; Nolte, 2011) and its fixation in rotary and vertical axes reduces efficiency in activation of flexors and extensors and power output between upper body and lower body (Jones, 2011). Mentioned authors concluded that ergometers should be considered as a cross-training tool for rowers and cannot replace on-water rowing.

On basis of these previous investigations, this present preliminary case study aimed to report differences in synergies organizing the muscular coordination and structure of timing between rowing on a single scull (SS) versus modelled rowing on an ergometer Concept 2 (C2). We considered surface electromyography (sEMG) to identify timing and muscle synergies, for a wider understanding of involved motor control patterns.

methods

Subject

Selected highly trained elite class female athlete volunteered on this study. Participant had seven years of experiences of continual competitive practise in rowing on a single scull as well as on an ergometer Concept 2. Athlete had technically fixed locomotive routine and no objective difficulties. Prior to study, athlete was fully informed about the kinesiology study and signed an informed consent form about the research approved by the Ethics Committee of the Faculty of Physical Education and Sport of Charles University in Prague. The study was performed in accordance with the guidelines of Declaration of Helsinki 2006. Testing was done in February 2015 by a team trained in sEMG research and took place in the Bohemians Rowing club in Prague.

Measurements

After individual warm up subject completed three of two min. experimental sessions at pace 22 strokes per minute, included three min. rest among them on an ergometer Concept 2 model D PM3. After ten min. rest subject repeated three of two min. on three min. rest testing at the same pace on a single scull. Rowing pace was calculated by determining power output for subject on her average 500 m split during a 2.000 m trial. Subject was instructed to achieve 80% of maximal heart rate and repeat similar strokes in sessions. Heart rate was tracked with a Polar 1 heart rate monitor (Polar Electro Oy, Kempele, Finland).

16 muscles were evaluated on the left side of the body: m. biceps brachii – long head (BB), m. trapezius med. (TrM), m. deltoideus med. (DeM), m. triceps brachii (TB), m. pectoralis major (PM), m. serratus anterior (SA), m. latissimus dorsi (LD), m. erector spinae (ES), m. external abd. oblique (EAO), m. rectus abdominis (RA), m. gluteus maximus (Gmax), m. gluteus medius (Gmed), m. rectus femoris (RF), m. biceps femoris (BF), m.

semitendinosus (Sem), m. vastus lateralis (VL). Measured muscles were chosen on behalf of the preliminary case study. Selected muscles embody the most telling variance. Laterality was not examined, because results of the preliminary were not conclusive. As the rowing is not a natural locomotion, we have not mentioned muscular chains.

Muscular activity was recorded using portable measuring device working on basis of EMG potentials. Biomonitor ME 6.000 (Mega Electronics Ltd., Kuopio, Finland) providing 16 channels, used sampling frequency was set up to 1.000Hz. The device was carried on the athlete's body. Ag/AgCl electrodes Kendall (Bio-Medical Instruments Inc., Clinton Township, MI, USA) were used. Followed the recommendations of SENIAM (2015) testing facilities met the prescribed criteria according recommended standards to minimize measurement errors. Acquired data were transferred to PC and processed in MegaWin software (Mega Electronics Ltd., Kuopio, Finland) and analysed in Matlab 2013a software (MathWorks, Inc., Natick, MA, USA).

Data analysis

Acquired data were processed in MegaWin software. Than algorithmically analysed in Matlab 2013a, conducted and evaluated using custom code. Presented results are based on data's linear signal envelope. The raw EMG signal was high-pass filtered (Butterworth 6th filter, cut-off frequency 20Hz) due to the artefacts elimination. Then fully rectified and low-pass filtered (Butterworth 6th filter, cut-off frequency 20Hz) EMG signal was used to create linear envelopes. The value of cut-off frequency 20Hz was chosen to preserve details in signal envelope and hence the time precision in muscle activity detection task. The signal processing met prescribed criteria in accordance the recommendations of SENIAM (2015) and ISEK (2015) standards.

The rowing cycles were defined due to positions of consecutive local maxima in timing of linear signal envelope. The boundaries of movement cycles are calculated by using standard Matlab function "findpeak" with a parameter of "minipeakdistance". The parameter value is equal to 70% of average movement period estimation. The average period estimation is based on the autocorrelation function applied to the signal envelope. The evaluation of muscle activity is supported by interpretation of mean EMG signal envelope of all channels. EMG signal envelopes are segmented due to individual movement cycles and segments are linearly time-interpolated over a 1000-point time base. The segments with interpolated envelopes are arranged in a matrix A that has 1000 columns and number of rows corresponds to count of identified movement cycles. Mean of the signal envelopes is calculated like the arithmetic mean applied on every column from the matrix A. In the last step is the mean signal envelope smoothed by 100-point moving average filter. The normalized time base 1000 point is chosen like optimal value for parametrization of mean muscle activity. The normalized time base corresponds to one second interval due to the sample frequency 1000Hz and is transformed into the range 0 – 100% mean movement cycle for presentation in Figure 1 (Špulák, 2016).

The muscle activity timing was detected using adaptive threshold detector separate in every channel. First step of detection requires identification and analysis of significant local extrema in mean signal envelope. Local extrema are sorted according the amplitude ratios of extrema. Significant extrema positions in mean movement cycle are transformed consequently into individual movement cycles. Every potential activation is represented by a pair of time positions of local minimum in signal envelope. Position of minimum value is redefined in range 5% of movement cycle length. Maximum value of signal envelope used for adaptive thresholding is defied in range limited by a pair of time positions of local minimum. Threshold is defined as 20% of difference between maximum and minimum of signal envelope. Onset threshold is calculated by first minimum extrema amplitude and offset by second minimum extrema amplitude. The muscle activity is detected if the signal envelope range onset threshold. The offset is detected analogically by using offset threshold. Muscular contraction timing was detected using threshold detector described in (Špulák et al. 2014).

The muscle activity detected in all movement cycles is subsequently transformed to normalized time base in range 0-100%. Processing is applied separately in every channel and activation identified in mean movement cycle. Mean muscle activation is represented by distributions of onsets and offsets timing in mean movement cycle. The first, second and third quartile is determined is distributions of onsets and offsets timing. Activation in normalized base represented by rectangle which shape of left and right side marks quartiles of activity timing Figure 1 shows average muscle activity identified in all cycles. Number of included movement cycles used for evaluation is denoted in column on the right side of graph. The amplitude of mean envelopes is normalized to global maximum value in envelope due to improve resolution in amplitude. Descriptive statistics included mean ± standard deviation (SD) of muscle activity are summarized in table. 1. The local extremes of mean envelopes were analysed and detections in signal envelopes were done. Observation was completed by kinematic analysis of movement due to the artefacts elimination by digital camera SONY HDR-SR12 (Sony Co., Tokio, Japan) connected by triggers to the measuring device.

Statistical analysis

The comparison of C2 and SS muscle activity was evaluated by visual inspection of mean envelopes and mean muscle activity but also by using Pearson correlation coefficients (r). Correlation coefficients are determined for a pair of mean envelopes in every channel. The muscle activity was assessed using tree criteria: correlation r, rmax and the lag time. The correlation coefficients were calculated by using standard Matlab function xcorr with option ‚coef'. The coefficient r is defined like cross-correlation between average signal envelopes, rmax is defined like maximum value of cross-correlation function between average signal envelopes in identical muscle for C2 and SS activity. Lag time corresponds with time shift in maximum value of correlation rmax. Table 3 shows coefficients and confidence intervals of rmax with level of significance alpha 0,05. The statistical test was applied in order, to verify the hypothesis of no correlation. The test ensures elimination of random chance to accept large correlation value when the true correlation is zero. Table 3 contains the values of probability and values less than 0,05 confirms the significant result. The process was referred in analogical application in (Turpin, Guével, Durand, & Hug, 2011b).

The inter-group comparison of mean EMG envelopes was computed by application of Spearman's rank correlation coefficient (r) between each pair of measured muscles. The onsets and cessations of EMG activity were time-normalized and merged for all movement cycles. Descriptive statistics included mean ± standard deviation (SD) was calculated for timing of each muscle activity.

Results

EMG envelopes were compared to the ensemble of averaged EMG linear envelopes for overall measured muscles during both movement patterns. The graphic records of mean EMG curves and onsets and cessations of the muscles activity during rowing stroke are depicted into the Figure 1 and Figure 2. We suppose that the positive high value of Pearson correlation coefficient proves similarity of muscle activity profiles and synergies organizing the muscular coordination.

Figure 1. The graphic records of mean EMG curves, onsets and cessations of the muscles activity during rowing stroke on SS (A) and C2 (B).

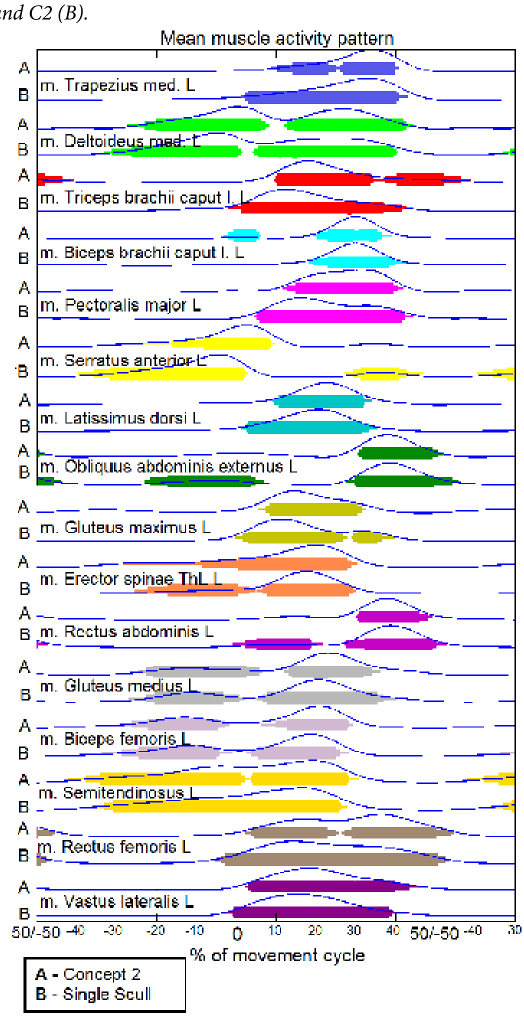


Figure 2. The graphic records of mean EMG curves, onsets and cessations of the muscles activity during rowing stroke on SS (green curve) and C2 (red curve).

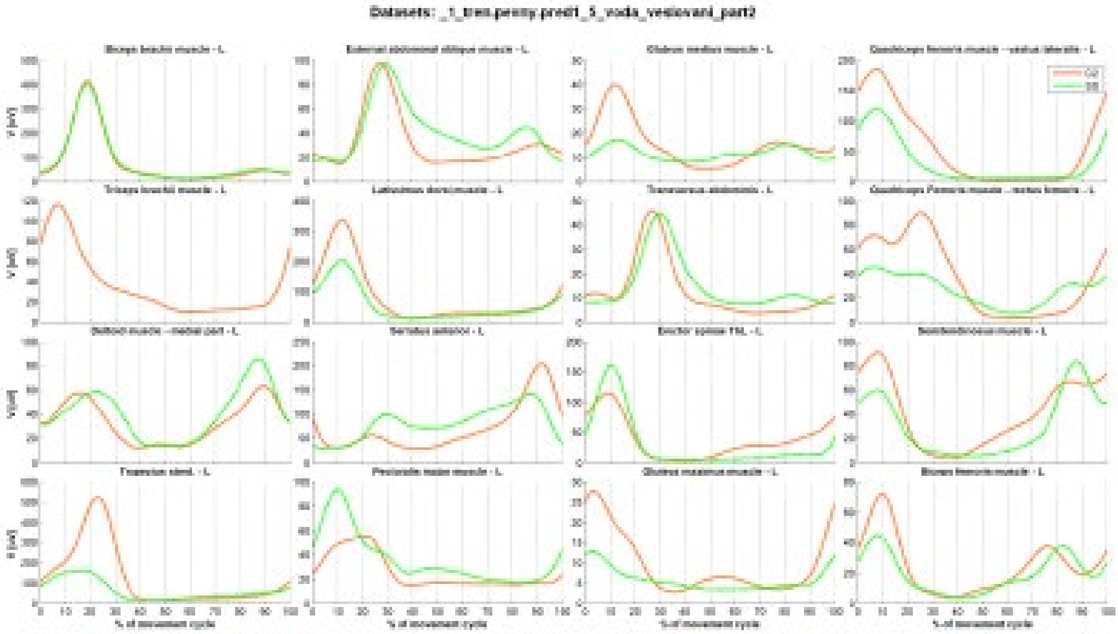


Table 1 and Table 2 illustrate numeric results of the inter-individual similarity indices of onsets and cessations for each channel. In ranging interval -50% – 50%, cycle initiation pertains 0%. The correlation coefficients for all observed muscles are depicted into Table 3. Results of muscular activity timing was inter-locomotive different, concretely lag of onsets on the C2 behind the onsets of the SS.

Table 1 Mean delay of onsets of muscle activity ranging interval -50% – 50%. Detected by threshold detector.

	C2 Act %	**SS Act %**
Measured muscles	Mean ± SD	Mean ± SD
m. trapezius med.	-0.94 ± 7.20	-20.09 ± 6.08
m. deltoideus med.	-31.37 ± 5.66	-49.31 ± 4.95
m. triceps brachii caput l.	-10.09 ± 3.95	-22.63 ± 9.35
m. biceps brachii caput l.	7.69 ± 3.62	2.49 ± 5.56
m. pectoralis major	-10.39 ± 2.91	-19.50 ± 6.49
m. serratus anterior	-38.57 ± 6.28	19.04 ± 2.79
m. latissimus dorsi	-13.23 ± 3.30	-15.42 ± 3.44
m. obliquus abdominis ext.	9.61 ± 3.01	0.46 ± 2.48
m. gluteus maximus	-12.10 ± 2.93	-13.53 ± 6.32

Table 2. Mean delay of cessations of muscle activity ranging interval -50% – 50%. Detected by threshold detector.

	C2 Act %	**SS Act %**
Measured muscles	Mean ± SD	Mean ± SD
m. trapezius med.	22.94 ± 8.18	4.74 ± 1.20
m. deltoideus med.	24.64 ± 2.97	27.59 ± 8.81
m. triceps brachii caput l.	20.10 ± 5.63	24.65 ± 12.32
m. biceps brachii caput l.	19.99 ± 3.41	19.73 ± 7.40
m. pectoralis major	3.19 ± 4.95	9.39 ± 6.56
m. serratus anterior	-14.03 ± 4.62	-25.72 ± 2.12
m. latissimus dorsi	10.03 ± 3.11	13.87 ± 5.28
m. obliquus abdominis ext.	30.42 ± 2.79	25.86 ± 7.08
m. gluteus maximus	4.03 ± 2.24	5.00 ± 1.55
m. erector spinae ThL	11.56 ± 4.96	11.47 ± 4.69
m. rectus abdominis	29.43 ± 2.82	39.64 ± 3.99
m. gluteus medius	21.05 ± 6.03	13.34 ± 10.06
m. biceps femoris	6.97 ± 3.36	6.17 ± 6.17
m. semitendinosus	7.64 ± 3.11	0.82 ± 4.49
m. rectus femoris	33.74 ± 3.21	40.90 ± 2.49
m. vastus lateralis	19.89 ± 7.85	22.26 ± 8.66

Table 3. Spearman's rank correlation coefficients (r) comparing mean EMG waveforms of SS and C2: r (max) indicates the best time delivery between EMG waveforms, r (no shift) indicates the correlation value expect of time delivery between EMG waveforms. Alpha 0.05.

Measured muscles	r (max)	r (no shift)
m. trapezius med.	.9629	.7826
m. deltoideus med.	.8849	.8823
m. triceps brachii caput l.	.9214	.9149
m. biceps brachii caput l.	.9988	.9988
m. pectoralis major	.9230	.9136
m. serratus anterior	.8190	.7374
m. latissimus dorsi	.9952	.9931
m. obliquus abdominis ext.	.9260	.9217
m. gluteus maximus	.9471	.9471
m. erector spinae ThL	.9571	.9571
m. rectus abdominis	.9724	.8939
m. gluteus medius	.9626	.9626
m. biceps femoris	.8954	.8954
m. semitendinosus	.9671	.9671
m. rectus femoris	.9597	.9597
m. vastus lateralis	.9665	.9665

Discussion

In our analysis, both rowing conditions was accompanied by muscle patterns. These indicated neuromuscular control to adapt to various mechanical constraints. We observed that the inventory of rowing tasks was achieved through modification of muscle loadings but not muscle synergy structure in agreement to the synergy studies on rowing (Marcolin et al., 2015; Shaharudin, Zanotto, & Agrawal, 2015; Turpin, Guével, Durand, & Hug, 2011a).

The aim was to consider similar kinesiological movement contents, that are the coordination and timing of 16 selected muscles of the body, during rowing on a single scull and rowing on an ergometer Concept 2 D PM3, even though there are considerable differences on the outer shape of the movement. In rowing, symmetrical involvement and effective coordination of the muscles is needful to reach maximal effort, since a non-optimal strategy could limit the power output and the limb motion (Wilson, Gordon E Robertson, & Stothart, 1988). Rowing on an ergometer Concept 2 showed the same number of muscle synergies in agreement to Marcolin et al. (2015), which indicated inter-locomotive similarity, but cross-plots showed different coordinative patterns. Thigh multi-joint muscles play role in transferring force generated from the foot stretcher to the trunk (Guével, Durand, & Hug 2011; Hofmijster, Van Soest, & De Koning, 2008). At the transition point, eccentric contraction was immediately followed by a concentric contraction, which was characterized by increased Sem neuromuscular activity on a C2 that likely served to accelerate the mass of the rower. This type of forceful Sem activity could not be performed on a SS because of the lower inertial mass of the boat relative to the body mass of rower. Observed trend may be explained by the fact, that in the stationary conditions, rowers need to accelerate their body mass to generate force at the handle. The patterns of neuromuscular activity met in agreement with the report from Rodriguez (1990). The graphic records of EMG curves showed high co-contraction of all measured muscles and approved its equality during both observed physical activities. Comparing rowing on C2 to SS, muscles showed different timing and strategy of muscle recruitment especially during the propulsive phase. Figure 1 suggests that muscles activity was not orthogonal. The most variable pattern was observed in the SA. Coactive SA and EAO create on SS linked chain.

Similar values indicate moderate variability of mean waveforms. The results in Table 3 support the hypothesis about similarity of the patterns of measured physical activities. All muscles showed high value of Spearman's rho, which indicates similar muscle activation during both movement patterns. Significant correlations approximated 0.9.

Limitation of this preliminary case study was low number of tested persons (one), therefore the results of this case study cannot be generalized to the entire Czech rowing population. Due to extend of the study, it would be appropriate to do further research.

Conclusion

Rowing on C2 and SS showed the same number of muscle synergies, but the muscle loading was different. Rowing on SS emphasized on earlier onsets and cessations of muscle loading. Video analysis has shown that the earlier beginning of the muscle activation during rowing on SS is a consequence of different fulcrum. This finding is consistent with the findings of Nolte (2011).

Results of this preliminary case study could improve our current understanding, regarding the strategy of the CNS to remain efficient in different mechanical constraints. Considering the use of C2 as training and testing device for rowers, we give a basis to the future research. Our recommendation, to eliminate consequences of artificial strengthening on a rowing machine, is to work in 15 minutes of rowing after the session to simulate right locomotive routine.

References

1. Guével, A., Boyas, V., Guilhard, V., Cornu, C., Hug, F., & Nordez, A. (2011). Thigh muscles activities in elite rowers during on-water rowing. *International Journal of Sports Medicine, 32* (2), 109-116.
2. Hofmijster, M. J., Van Soest, A. J., & De Koning, J. (2008). Rowing skill affects power loss on a modified rowing ergometer. *Med. and Sci. in Sport Exercise, 40* (6), 1101-1110.
3. Christov, R., Ivanov, S., & Christov, R. (1989). Problems of the biomechanical analysis of the rowing technique in real and test conditions. In: Tsarouchas, L. (ed.) et al. *Biomechanics in Sports V: proceedings of the Fifth International Symposium of Biomechanics in Sports*. Hellenic Sports Research Institute, Olympic Sports Center of Athens, 269-275.
4. ISEK International society of electrophysiology and kinesiology. (2015). *Standards for reporting EMG data.* Retrieved from http://www.isek-online.org/standards_emg.html
5. Jones, D. I. (2011). *Upper versus lower body contribution to the rowing stroke.* (Dissertation, NK Electronic Theses and Dissertations Centre & Cleveland State University. Cleveland, Ohio, USA).
6. Kleshnev, V. (2016). *The Biomechanics of Rowing.* Ramsbury, UK: The Crowood Press Ltd.
7. Marcolin, G., Lentola, A., Paoli, A., & Petrone, N. (2015). Rowing on a boat versus rowing on an ergo-meter: a biomechanical and electromyographical preliminary study. *Procedia Engineering, 112* (1), 461-466.
8. Nevill, A. M., Allen, S. V., & Ingham, S. A. (2011). Modelling the determinants of 2000m rowing ergometer performance: a proportional, curvilinear allometric approach. *Scandinavian Journal of Medicine & Science in Sports, 21* (1), 73-78.
9. Nolte, V. (2011). *Rowing Faster.* Champaign: Human Kinetics.

10. Rodriguez, R. J. (1990). Electromyographic analysis of rowing stroke biomechanics. *Journal of Sports Medicine and Physical Fitness, 30 (*2), 103-108.
11. SENIAM (2015). The Surface Electromyography for non-invasive assessment of muscles. Retrieved from http://www.seniam.org.
12. Shaharudin, S., Zanotto, D. & Agrawal, S. (2015). Muscle synergies of untrained subjects during 6 min maximal rowing on slides and fixed ergometer. *Journal of Sport Science and Medicine, 13*(4),793-800.
13. Špulák, D. (2015). *Zpracování povrchových elektromyografických signálů.* Dizertační práce. Praha: ČVUT FEL.
14. Špulák, D., Čmejla, R., Bačáková, R., Kračmar, B., Satrapová, L., & Novotný, P. (2014). Muscle activity detection in electromyograms recorded during periodic movements. *Comput in Biol and Med, 47* (2), 93-103.
15. Turpin N. A., Guével, A., Durand, S., & Hug, F. (2011a). Effect of power output on muscle coordination during rowing. *European Journal of Applied Physiology, 111*(12), 3017-3029.
16. Turpin, N. A., Guével, A., Durand, S. & Hug, F. (2011b). Fatigue-related adaptations in muscle coordination during a cyclic exercise in humans. *Journal of Experimental Biology, 214* (19), 3305-3313.
17. Wilson, J.-M. J., Gordon E Robertson, E., & Stothart, J. P. (1988). Analysis of lower limb muscle function in ergometer rowing. *International Journal of Sport Biomechanics, 4* (1), 315-325.

Author: Mgr. Martina Zbořilová
E-mail: zborilova.ma@gmail.com

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