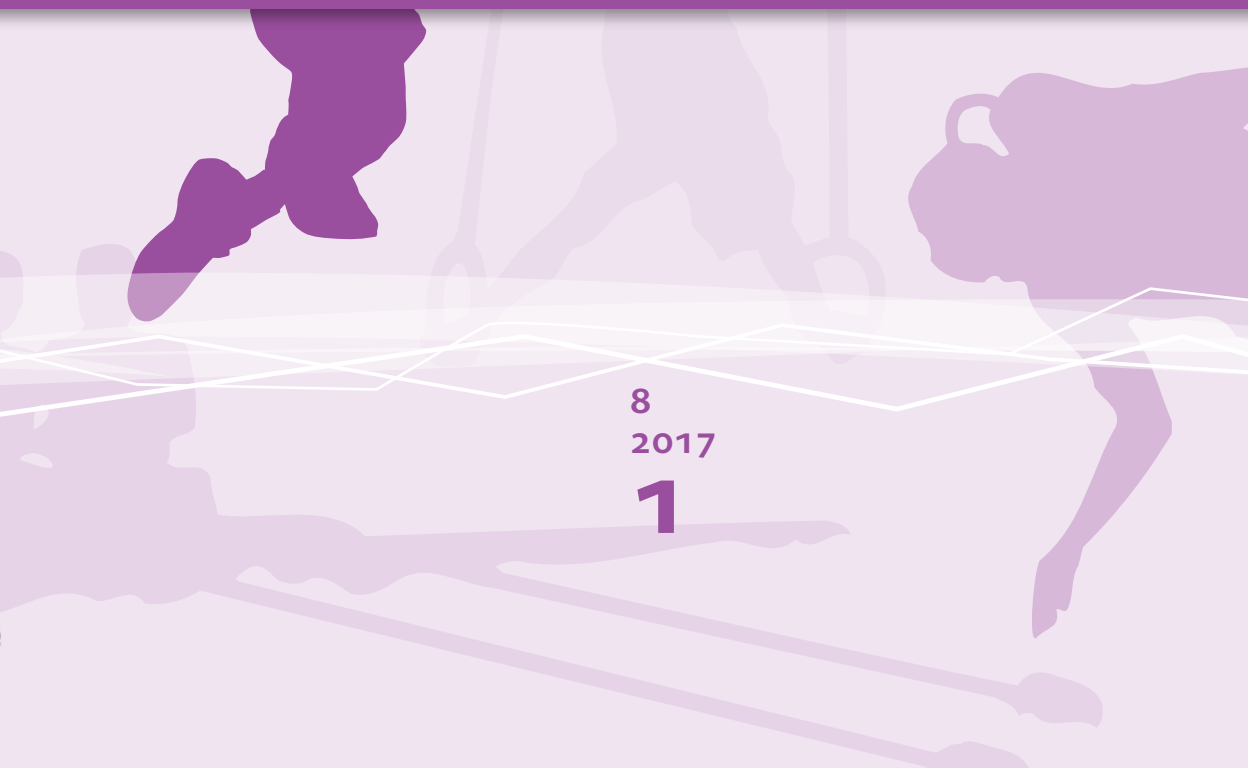




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EDITORIAL

At the very beginning, during the process of formation, Annales Kinesiologiae has set itself the objective to answer the questions regarding kinesiological science and to reveal the issues that its distinctly interdisciplinary and integrative nature reveals on a daily basis. Critical consideration of scientific research questions mirrored in the kinesiology science thus faces us with the responsibility towards science, profession and society, individuals and groups, direct users of the findings and the conclusions that we offer. On numerous occasions, the factors of the positive impact of physical / sport activities on both health and quality of life have already been studied, tested and proven. The objectives of the new and advanced research into these factors are, among other, the search for new opportunities, shedding light on grey areas, opening new niches ... What is extremely important is the flexibility of these factors regarding each individual role of man in modern society, the profession, the environment and, especially, gender and age. By studying the differences and mechanisms and by differentiation of the selected interventions of the adjusted dimensioning and the content of exercise in real time, we can seek higher performance, better management of these factors, and especially, increased efficiency.

The four original and review scientific contributions published in Issue 1, Volume 8 of Annales Kinesiologiae reveal the perspective of examining the young and the old, men and women, in specific situations, also in sports where the aim is, unfortunately, not always directed only at the quality of an individual and their performance, but also at the competition and the results, here and now.

The issue is introduced by a rather methodological article looking into the question *Is Specific Motor Test Enough to Evaluate New Alpine Ski Knowledge in Ski Beginners?* The motor test using continuous lateral jumps in dictated tempo – SKILJ is being used to evaluate new alpine ski knowledge and is the focal point of the article which aims at determining whether the results of such motor tests can be used to evaluate the level of acquired knowledge of ski beginners.

Tensiomyography as a tool for measuring muscle contraction time and maximal radial displacement of biceps femoris is described in the following article. A division between the sedentary participants and those who were regularly engaged in recreational sports activities has been observed and recognized.

Two articles in this volume introduce the review studies that originate from the results of the international research project PANGeA (Physical Activity and Nutrition for Great Ageing). It is becoming increasingly evident that both motor as well as cognitive exercise is essential for healthy ageing. These are the topics covered in the article on *Exercise and the Ageing Immune System* and the article which present the *Benefits of Motor / Cognitive Exercise with recommendations for third age*.

As usual, the section Reviews and Reports in this journal continues with a series of reports from various events. First with a report from the second round table »*A Kinesiologist in the Labour Market*« which was organized by the Association of Kinesiologists of Slovenia after a very successful first round table. The participants introduced some

very interesting topics that shared their vision of kinesiology and recommendations for the future. The journal rounds up with reports from three conferences, which usually summarize various aspects of research in kinesiology.

Prof. Rado Pišot, Ph.D.
Editor-in-Chief and Managing Editor

UVODNIK

Annales Kinesiologiae si je že v sami zasnovi in procesu nastajanja zastavila nalogo odgovarjati na vprašanja kineziološke znanosti in razkrivati probleme, ki jih njen izrazito interdisciplinaren in integrativen značaj vsakodnevno odpira. Kritična obravnavna znanstveno raziskovalnih vprašanj, ki se zrcalijo v ogledalu kineziološke znanosti, pred nas tako postavlja odgovornost do znanosti, stroke in družbe, posameznika in skupin, neposrednih uporabnikov ugotovitev in zaključkov, ki jih ponujamo. Dejavniki pozitivnega vpliva gibalne/športne aktivnosti na zdravje in kakovost življenja so bili nešteto preučevani, preverjeni in dokazani. Vedno nove in naprednejše raziskave teh dejavnikov si za cilje med drugim postavljajo iskanje novih možnosti, osvetljevanje sivih con, odpiranje niš ... Gotovo je izredno pomembna njihova prilagodljivost posamezni vlogi človeka v sodobni družbi, poklicu, okolju predvsem pa spolu in starosti. S preučevanjem razlik in mehanizmov ter diferenciacijo izbranih intervencij, prilagojenega dimenzioniranja in vsebine vadbe v realnem času, lahko iščemo večji učinek, lažje upravljanje omenjenih dejavnikov, predvsem pa njihov boljši izkoristek.

V štirih izvirnih in preglednih znanstvenih prispevkih, objavljenih v prvem zvezku 8. letnika revije Annales Kinesiologiae, nam avtorji odstirajo pogled na preučevanje mlajših in starejših, moškega in ženskega spola, v specifičnih situacijah in nenazadnje v športih, kjer cilj, žal, ni vedno usmerjen le v dobrobit posameznika in njegovo učinkovitost, temveč pogosto predvsem v tekmovalni rezultat tukaj in zdaj.

Na bolj metodološko področje posega prispevek *Je predlagani motorični test veljaven test znanja alpskih smučarjev začetnikov?* Motorični test z izvajanjem zaporednih lateralnih odskokov po ritmu – SKILJ je osrednja tema prispevka, v njem pa avtorji preverjajo, če lahko rezultate tovrstnega testa uporabimo za preverjanje stopnje pridobljenega znanja smučarjev začetnikov.

S tenzimiografsko metodo pridobljen čas kontrakcije in maksimalni odmik trebuha dvoglave stegenske mišice obravnavajo avtorji članka *Z metodo tenzimiografije izmerjene razlike med časom kontrakcije in odkikom mišice med različno starimi in fizično aktivnimi skupinami*. Avtorji so poleg nekaterih drugih opažanj med udeleženci raziskave na osnovi dobljenih rezultatov meritev opazili delitev na dve skupini glede na rednost ukvarjanja s fizično aktivnostjo, in sicer na sedeče in na tiste, ki so se redno ukvarjali z rekreativno obliko športne dejavnosti.

Dva članka iz tokratne številke uvajata niz preglednih študij, ki so rezultat aktivnosti mednarodnega raziskovalnega projekta PANGeA. Vse bolj evidentno je, da imata tako motorična kot kognitivna vadba pomembne učinke na zdravo staranje. S tovrstnimi tematikami se ukvarjajo avtorji članka *Gibanje in imunski sistem med procesom staranja* ter članka *Prednosti in koristi gibalne in/ali kognitivne vadbe: pregled področja s priporočili za tretje življenjsko obdobje*.

Kot običajno, tudi tokratno številko v rubriki Ocene in poročila nadaljujemo s poročili iz raznih dogodkov. Najprej je to kratko poročilo iz druge okrogle mize »Kineziolog na trgu dela«, ki jo je Društvo kineziologov Slovenije organiziralo po zelo odzivni prvi tovrstni okrogli mizi. Tudi na tem srečanju so bile predstavljene številne zanimive

teme, predvsem pa so sodelovali številni zanimivi gostje, ki so udeležencem predstavili svojo vizijo kineziologije in priporočila za prihodnost. Revijo pa zaključujejo poročila iz treh konferenc, ki praviloma povzemajo različne vidike obravnave kinezioloških vprašanj.

prof. dr. Rado Pišot,
glavni in odgovorni urednik

IS SPECIFIC MOTOR TEST ENOUGH TO EVALUATE NEW ALPINE SKI KNOWLEDGE IN SKI BEGINNERS?

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ABSTRACT

The present research aims at determining whether the results of specific motor tests (continuous lateral jumps in dictated tempo – SKILJ) are a sufficient measure to evaluate the level of acquired alpine ski knowledge of ski beginners. Twenty four alpine ski naïve male participants with comparable performance levels and no record of injuries in the preceding six months were included in the study. They were tested on SKILJ test Microgate Optojump Next system prior to participating in a structured alpine ski school program. After completing the ski school program, the participants' knowledge of short turn was tested by five judges. Correlation coefficients between the five judges for the short turn element were all high and statistically significant, implying judges' objectivity in grading alpine ski knowledge. On the other hand, there was no statistically significant correlation between lateral jumps in predefined pace and the acquired knowledge of short turn skiing technique. Therefore, we conclude that the movements executed during alpine skiing with continuous connecting of short parallel turns are much more complicated than the movements needed during the performance of SKILJ which cannot fully depict alpine skiing.

Keywords: recreational level alpine skiers, motor abilities, motor skills learning efficiency.

JE PREDLAGANI MOTORIČNI TEST VELJAVEN TEST ZNANJA ALPSKIH SMUČARJEV ZAČETNIKOV?

IZVLEČEK

Cilj raziskave je bil ugotoviti ali rezultati specifičnih motoričnih testov (zaporedni lateralni odskoki po ritmu – SKILJ) omogočajo vrednotenje napredka smučarjev začetnikov pri pridobivanju veščin alpskega smučanja. V raziskavo je bilo vključenih štiriindvajset moških smučarjev začetnikov s primerljivimi sposobnostmi, ki vsaj šest mesecev pred izvedbo raziskave niso bili poškodovani. Preden so se preiskovanci udeležili strukturirane šole alpskega smučanja, smo jih motorično testirali s testom SKILJ (Microgate Optojump Next). Po zaključenem šolanju alpskega smučanja, je skupina petih sodnikov vsakemu preiskovancu ocenila smučanje v ozkem hodniku. Korelacijski koeficienti med ocenami petih sodnikov so bili visoki in statistično značilni, kar nakazuje objektivnost sodnikov pri ocenjevanju. Hkrati pa nismo zaznali statistično značilne povezave med lateralnimi odskoki z definiranim ritmom in pridobljenimi znanji smučanja v ozkem hodniku. Ugotovili smo, da je gibanje, ki ga alpski smučar izvaja med kontinuirano in povezano izvedbo ozkega hodnika mnogo bolj zapleteno kot gibanje med izvedbo testa SKILJ in da slednji ne more v celoti orisati alpskega smučanja.

Ključne besede: alpski smučarji rekreativci, motorične sposobnosti, učinkovitost motoričnega učenja

INTRODUCTION

Most of the cyclic sports include the performance of certain rhythmical movements that are systematically repeated. The movements that are repeated in alpine skiing are turns (Oreb, Vlašić, Cigrovski, Prlenda, & Radman, 2011). Effective and meaningful interconnection of individual parts of a turn, as well as connecting multiple turns into a whole represents a skiing rhythm (Cigrovski & Matković, 2015). The rhythmic performance of multiple turns is intuitive performance without any prior thoughts on each part of the turn. The rhythm of the turns, maintaining good balance on the skis, and smooth sliding of the skis all influence our skiing technique, making it more efficient (Loland, 2009; Cigrovski & Matković, 2015). When analyzing competitive level skiers, slalom discipline is the one in which rhythm is often commented with respect to the set course of gates series (Waibel, Huber, & Spitzenpfell, 2009). Slalom turns are short and in a narrow corridor, they are a modified version of short turn element. Although the rhythm of turns is also present in the wider corridor during the technique and in other alpine skiing disciplines, according to Waibel and coworkers (2009), slalom is a

discipline in which oscillations in the change of rhythm during a continuous connection of multiple turns are visible and recorded. From the aspect of recreational skiers, it is known that the success of alpine ski learning depends upon multiple factors, and among the most important are: learning conditions, the expertise of the ski instructor and the abilities and motivation of the ski beginners (Loland, 2009). Although one would expect explosive leg strength to be equally important for beginners as it is for competitive level skiers, tests for its assessment in alpine ski beginners failed to prove correlation with the success of ski learning suggesting that explosive leg strength is not critical in the beginning phases of learning (Neumayr et al., 2003). On the other hand, of all the motor abilities, it is balance that probably differs those ski beginners who will acquire ski knowledge sooner from those whose adoption of ski knowledge will go slower (Malliou et al., 2004; Ružić, Radenović, & Tudor, 2008; Cigrovski, Franjko, Rupčić, Baković, & Matković, 2016). Interestingly, much less is known about the correlation of coordination in the rhythm with the effectiveness of adopting ski knowledge. It can be assumed that ski beginners who have developed this ability at a higher level will adopt the elements of ski technique that are continuously linked to overcoming the ski terrain more quickly. Currently, the use of simulation devices to improve the motor performances of athletes is becoming increasingly popular. Ski simulators are specifically constructed to enable alpine skiers' adequate conditioning trainings before going to the ski terrains (Straub, 2013). It is expected that ski-simulator training during the off-season, when access to real slopes is limited, would benefit skiers. Existing ski-simulator studies largely verify the training effect through observation of changes in the movement pattern, while only few verify the effectiveness of reality-based ski simulator (Nam & Woo, 2007; Lee, Kim, & Roh, 2012). Moreover, simulation devices are used at recreational level with the purpose to predict the tempo of learning new activity, suggest individual approaches to each beginner, allow people to enjoy skiing during non-winter season and practice ski-turn motor performance (Panizzolo, Marcolin, & Petrone, 2013). With respect to the aforementioned, data on importance of specific motor abilities learned and tested by ski simulator are scarce, but according to Nourrit-Lucas, Zelic, Deschamps, Hilpron, and Delignières (2013), coordination variables tend to be among the most important factors for valid assessment of learning and retention of alpine skiing (Nourrit-Lucas et al., 2013). Skiing is an activity that requires a coordination between upper and lower body, with special accent on leg muscles that need to be strengthened. During ski turns, especially short turns skiers are constantly performing lateral leg movements which are simulated by lateral jumps during training. The use of ski simulators enables lateral movements / jumps to be performed more authentically to short turns. Repetition of lateral jumps or lateral leg movements on a ski simulator represents a certain rhythm that can be performed at different pace, also, the pace at which lateral jumps are performed can be adjusted to usual pace of turns during slalom skiing. Therefore, in the present research we wanted to determine whether the results in specific motor test (continuous lateral jumps – SKILJ) are sufficient to evaluate the level of acquired alpine ski knowledge of ski beginners.

METHODS

Participants

Overall, 24 male participants were included in the study. They were all students of School of Kinesiology, University of Zagreb, who exhibited comparable performance levels and had no record of injuries in the preceding 6 months (age 23.4 ± 1.68 years). They were all ski beginners prior to inclusion in the present study, with no experience whatsoever in alpine skiing. The study was approved by Ethics Committee of the School of Kinesiology, University of Zagreb. Each participant voluntarily provided written informed consent before participating and was thoroughly informed about the study aims and procedures.

Variables

At the beginning, the participants were tested according to a specific SKILJ test, assessing their performance of lateral jumps in dictated tempo (fifteen jumps in a time unit) using Microgate Optojump Next system. The system consists of two bars; transmitting and receiving which communicate by LED lamps and calculate the duration of interruptions in the communication. The calculations measure the flight and contact times during the performance of a series of jumps with an accuracy of 1/1000 of a second. Moreover, the use of two cameras allows recording of the images of the tests performed, synchronizing them with the measured events. The participants were then included in a structured alpine ski program in identical conditions, and were afterwards tested on the short turn alpine ski technique. Short turns best represent the continuous connection of short unfinished parallel turns performed in a narrow corridor.

Research Protocol

The participants were first tested on SKILJ test for motor ability assessment. The test was repeated 3 times and the average result of each participant was used. Two parallel lines 30 cm apart were put on the ground; suggesting a minimal width of lateral jumps. The participants were asked to perform fifteen lateral jumps in the defined space. During the jumps they could use hand swings for the stability and adjusting the tempo of jumps. Intensity of the performance was tested in two variants. In variant one, participants chose their own tempo and intensity for lateral jumps, optimal take off and flight, while in variant two they had to perform 76 lateral jumps per minute (metronome). Variables that were selected and measured included: average contact with ground (contact / s), average duration of flight (flight / s), average power (power W / kg), average value of pace (RSI step / s), average jump height (height / cm).

Figure 1 Participant performing lateral jumps during the testing with Microgate Optojump Next system.



After taking the test, the participants were included in a ten-day alpine ski program. During the skiing program they all had identical conditions regarding the terrains in the ski center, the quality of ski equipment, the hours of daily learning and practice, the availability of ski instructors and the information on alpine skiing. The participants were randomized in three groups of eight, and when the program of alpine skiing finished they all joined one group, demonstrating the acquired knowledge of short turn. Five independent judges graded the demonstration of short turn on a scale from 1 to 5; where the grade 5 was given to participants with superb demonstration. Each grade was given upon previously defined criteria and each judge had to pay attention to a specific part of a turn. Judges' objectivity and homogeneity was tested in previous studies and therefore allowed their engagement in this research (Cigrovski, Matković, & Matković, 2008). Moreover, each participant was filmed during the demonstration of short turn, and afterwards the same judges once again evaluated the video of participants' short turn.

Statistical Methods

The results were analyzed by the Statistica statistical package version 12. To test the objectivity, the correlation coefficients between grades for short turn were calculated. Factor analysis was used to test judges' homogeneity. Basic descriptive parameters were calculated, assessing participants' motor ability (SKILJ). Pearson's coefficients were calculated for the evaluation of degrees of the correlation between motor ability (lateral jumps) and alpine ski knowledge (on-field demonstration of short turn and video analysis of the same element). The results were considered significant if $p < .05$.

Table 1: Correlation coefficients between grades given by five judges for the demonstration of short turn.

	judge 1	judge 2	judge 3	judge 4	judge 5
judge 1	1.00	0.75**	0.80**	0.77**	0.72**
judge 2		1.00	0.79**	0.79**	0.88**
judge 3			1.00	0.82**	0.82**
judge 4				1.00	0.78**
judge 5					1.00

* $p < 0.05$; ** $p < 0.01$

Correlation coefficients between the five judges for the short turn element are all high and statistically significant, implying judges' objectivity.

Data on judges' homogeneity are presented in Table 2.

Table 2: Results of first components given by judges during the short turn grading.

Element of ski technique	Components (factors)	Eigenvalue	% variance
short turn	1	4.17	83.38

Table 2 presents the eigenvalue of the principal component which fulfils the Guttman-Kaiser criterion ($\lambda=4.17$) and represents the knowledge of alpine skiing. The results suggest that all judges participating in the investigation graded the same item, i.e. alpine ski knowledge.

Basic descriptive parameters for the variables obtained in the SKILJ test and for the short turn are shown in Table 3.

Table 3: Basic descriptive parameters for the variables obtained in the SKILJ test and for the short turn.

	N	Mean	Max	Min	SD
SKILJ	24	1.95	1.17	2.41	0.31
short turn	24	3.70	2.00	5.00	1.02
VIDEO short turn	24	1.08	0.93	1.27	0.10
SKILJ avg	24	1.94	1.42	2.35	0.25

SKILJ = continuous lateral jumps; VIDEO short turn =grade for filmed short turn; SKILJ avg =SKILJ average result; Max=maximal; Min=minimal

Correlation between SKILJ test and the level of acquired alpine ski knowledge in short turn is presented in Table 4.

Table 4: Correlation between the SKILJ test and the level of acquired alpine ski knowledge in short turn.

	SKILJ	short turn	VIDEO short turn	SKILJ avg
SKILJ	1.00	0.05	-0.01	0.94*
short turn		1.00	0.11	0.11
VIDEO short turn			1.00	-0.10
SKILJ avg				1.00

* $p < 0.05$; ** $p < 0.01$

SKILJ = continuous lateral jumps; VIDEO short turn =grade for filmed short turn; SKILJ avg =SKILJ average result

The results show no statistically significant correlation between lateral jumps in predefined pace and the acquired knowledge of short turn ski technique.

DISCUSSION AND CONCLUSION

Alpine skiing is best characterized by repetition of ski turns, the basic motion for managing speed and direction during downhill descend (LeMaster, 2009). It is expected that different exercises or tests simulating specific ski movements used during off-

-season would benefit skiers in terms of training and maintaining their functional and strength capabilities. Significant interest has been shown in the use of motion analysis of ski turns to improve performance while performance of turns affects overall performance (Gwangjae et al., 2016). Although for recreational skiers one would expect similar training might help in learning or mastering specific movements important for ski technique it has not been proven repeatedly. For example, explosive leg strength which is of utmost importance for the success of competitive level skiers, did not show its correlation with success of ski learning during the beginning phases (Neumayr et al., 2003). On the other hand, balance is equally important for competitive skiers as it is for ski beginners, while those who have developed balance at the higher level also adopt ski knowledge more rapidly (Malliou et al., 2004; Ružić et al., 2008; Cigrovski et al., 2016). Although one would expect similar importance of coordination in the rhythm with the effectiveness of adopting ski knowledge, our results failed to demonstrate it with test lateral jumps. Lateral jumps are often used during competitive skiing trainings because they are like lower body and leg motion during skiing. They play a crucial role in the control of speed and direction during turns.

In this study, we found no statistical significance between the results achieved in the SKILJ test (testing lateral jumps) and learned level of short turn. Results suggest that the movements executed during continuous connecting few short parallel turns are much more layered (complicated) than the movements needed during the performance of SKILJ. Moreover, different ways of executing short turns and lateral jumps in the test additionally contributed to a lack of correlation between the two variables. Besides the biomechanical aspects of ski turn that have been studied with different methods and simulators, the analysis of movement helps in determining patterns of injury and subsequently leads to their successful prevention (Lee et al., 2012; Gwangjae et al., 2016). This is where the research with ski simulators is aimed at in the recent years (Lee et al., 2012). As alpine skiing is a specific motor activity primarily due to the conditions in which it is executed and the need for continuous rhythmic body movements while descending the slope in different width corridors, efforts are made in the development of specific training protocols and tests that would improve ski technique. Before making final conclusions about the existence of correlation between the results in SKILJ test and adoption of knowledge in short turn, we need to mention the study limitations. Firstly, it included a small number of participants. In succeeding studies, a larger sample of participants and participants of different age need to be included. If repeatedly one would find no correlation between SKILJ results and alpine ski learning, conclusion with greater certainty would be that we cannot predict success of learning short parallel turn with SKILJ. Once again it must be accentuated that the SKILJ test was taken and modified from conditioning training of the competitive level alpine skiers. Different lateral jumps in dictated tempo are systematically used during conditioning trainings of alpine skiers. Analogy with the mentioned led to the assumption that lateral jumps in predefined tempo of performance like that of short parallel turns will be in close correlation, but as previously mentioned in similar studies, the correlations although sometimes logical, do not always prove in the praxis (Neumayr et al., 2003).

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REFERENCES

- Cigrovski, V., & Matković, B. (2015).** Skiing technique carving. Zagreb (CRO): University of Zagreb, Faculty of Kinesiology.
- Cigrovski, V., Matković, B., & Matković, R. B. (2008).** Evaluation of objectivity and homogeneity of skiing knowledge grading process. In: D. Milanović, & F. Prot (Eds.), *Proceedings of 5th International Scientific conference on Kinesiology* (pp. 513–517). Zagreb: University of Zagreb, Faculty of Kinesiology.
- Cigrovski, V., Franjko, I., Rupčić, T., Baković, M., & Matković, B. (2016).** Correlation between balance, specific alpine skiing knowledge and situational efficiency in alpine skiing. *Acta Kinesiologica*, 10 Suppl., (1), 66–70. [VIEW ITEM](#)
- Gwangjae, Y., Young, J. J., Jinhyeok, K., Jin, Hae, K., Hye, Y. K., Kitae, K., & Siddhartha, B. P. (2016).** Potential of IMU sensors in performance analysis of professional alpine skiers. *Sensors*, 16(4), 463. doi:10.3390/s16040463 [VIEW ITEM](#)
- Lee, H. T., Kim, Y. J., & Roh, H. L. (2012).** Changes in the lower limb joint angle during the simulated skiing. *Journal of Physical Therapy Science*, 24(6), 471–474. doi: 10.1589/jpts.24.471 [VIEW ITEM](#)
- LeMaster, R. (2009).** Applications of physics education research to skiing pedagogy for coaches and instructors. In E. Müller, S. Lindinger, & T. Stöggl (Eds.), *Science and skiing IV* (pp. 347–355). Oxford (UK): Meyer & Meyer Sport.
- Loland, S. (2009).** Alpine skiing technique – practical knowledge and scientific analysis. In E. Müller, S. Lindinger, & T. Stöggl (Eds.), *Science and skiing IV* (pp. 43–58). Oxford (UK): Meyer & Meyer Sport.
- Malliou, P., Amoutzas, K., Theodosiou, A., Gioftsidou, A., Mantis, K., Pylianidis, T., & Kioumourtzoglou, E. (2004).** Proprioceptive training for learning downhill skiing. *Perceptual Motor Skills*, 99(1), 149–154. doi: 10.2466/pms.99.1.149-154 [VIEW ITEM](#)
- Nam, C. H., & Woo, B. H. (2007).** Kinematical analysis of up-down motion in ski simulator. *Korean Journal of Sport Biomechanics*, 17(3), 41–49. doi: 10.5103/KJSB.2007.17.3.041 [VIEW ITEM](#)
- Neumayr, G., Hoertnagl, H., Pfister, R., Koller, A., Eibl, G., & Raas, E. (2003).** Physical and physiological factors associated with success in professional alpine skiing. *International Journal of Sports Medicine*, 24(8), 571–575. doi: 10.1055/s-2003-43270 [VIEW ITEM](#)
- Nourrit-Lucas, D., Zelic, G., Deschamps, T., Hilpron, M., & Delignières, D. (2013).** Persistent coordination patterns in a complex task after 10 years delay: how validate the old saying »once you have learned how to ride a bicycle, you never forget!« *Human Movement Science*, 32(6), 1365–1378. doi: 10.1016/j.humov.2013.07.005 [VIEW ITEM](#)
- Oreb, G., Vlašić, J., Cigrovski, V., Prlenda, N., & Radman, I. (2011).** Relationship between rhythm and learning alpine skiing technique. In I. Prskalo, & D. Novak (Eds.),

- Proceedings of 6th FIEP European congress “Physical education in the 21st century-pupils competencies” (pp. 640–646). Zagreb: HRKS.
- Panizzolo, F. A., Marcolin, G., & Petrone, N. (2013).** Comparative evaluation of two skiing simulators as functional training devices for recreational skiers. *Journal of Sports Science and Medicine*, 12(1), 151–158. [VIEW ITEM](#)
- Ružić, L., Rađenović, O., & Tudor, A. (2008).** The predictive power of balance board: tests for «on-the-skis» balance performance. In D. Milanović, & F. Prot (Eds.), *Proceedings of 5th International Scientific conference on Kinesiology* (pp. 196–200). Zagreb: University of Zagreb, Faculty of Kinesiology.
- Straub, W. F. (1975).** Validation of a ski simulator. *Research Quarterly for Exercise and Sport*. American Alliance for Health, Physical Education and Recreation, 46(1), 92–99. doi: 10.1080/10671315.1975.10615309 [VIEW ITEM](#)
- Waibel, K., Huber, A., & Spitzenfell, P. (2009).** Performance analyses in alpine ski racing regarding the characters of slopes and course settings. In E. Müller, S. Lindinger, & T. Stoggl (Eds.), *Science and skiing IV* (pp. 565–572). Oxford (UK): Meyer & Meyer Sport.

DIFFERENCES OF THE TENSIOMYOGRAPHY-DERIVED BICEPS FEMORIS MUSCLE CONTRACTION TIME AND DISPLACEMENT BETWEEN DIFFERENT AGE AND FITNESS GROUPS

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ABSTRACT

Introduction: The aim of this study was to compare tensiomyography-derived biceps femoris muscle (BF) contraction time (T_c) and maximal radial displacement (D_m).

Methods: Ninety male participants were divided into three age groups: young adults (YA; 23.7 ± 4.3 years), middle-aged adults (MA; 46.7 ± 5.6 years), and older adults (OA; 64.2 ± 6.5 years). Furthermore, the participants were divided in two physical activity groups – the sedentary and those who were regularly engaged in recreational sports activities (at least three times a week). Tensiomyography (TMG) method was used to measure the BF D_m and T_c during isometric single-twitch maximal contraction.

Results: We found shorter T_c in active YA than sedentary YA ($P = 0.001$). Active YA had also shorter T_c than active OA ($P = 0.046$). Active YA had also a lower D_m than sedentary YA ($P = 0.031$), while pooled YA showed a trend towards a lower D_m than pooled MA ($P = 0.073$) and pooled OA ($P = 0.120$).

Discussion and conclusions: TMG data indicates a transition towards higher slow-twitch muscle fibre type with age and sedentary lifestyle. Furthermore, TMG data also indicates a lower muscle tone with age and sedentary lifestyle. Data obtained with TMG can be used to assess muscle imbalances in human body, which may be of clinical importance.

Keywords: tensiomyography, biceps femoris, lifestyle, aging, sport.

Z METODO TENZIOMIOGRAFIJE IZMERJENE RAZLIKE MED ČASOM KONTRAKCIJE IN ODMIKOM MIŠICE MED RAZLIČNO STARIMI IN FIZIČNO AKTIVNIMI SKUPINAMI

IZVLEČEK

Uvod: Namen pričujoče študije je bil primerjati s tenziomiografsko metodo (TMG) pridobljen čas kontrakcije (T_c) in maksimalni odmik (D_m) trebuha dvoglave stegenske mišice (BF).

Metode: Devetdeset moških udeležencev je bilo razdeljenih v 3 starostne skupine: mladi odrasli (YA; 23.7 ± 4.3 let), odrasli v srednjih letih (MA; 46.7 ± 5.6 let) in starejši odrasli (OA; 64.2 ± 6.5 let). Nadalje so bili udeleženci razdeljeni v 2 skupini glede na rednost ukvarjanja s fizično aktivnostjo- sedeči in tisti, ki so se redno ukvarjali z rekreativno obliko športne dejavnosti (vsaj 3-krat na teden). Metoda TMG je bila uporabljena za merjenje odziva parametrov D_m in T_c mišice BF na en maksimalni dražljaj.

Rezultati: Ugotovili smo, da imajo aktivni YA krajši T_c od sedečih YA ($P = 0.001$) in tudi krajši T_c od aktivnih OA ($P = 0.046$). Aktivni YA imajo nižji D_m kot sedeči YA ($P = 0.031$). Za YA je značilen trend nižjega D_m v primerjavi z MA ($P = 0.073$) in z OA ($P = 0.120$).

Razprava in zaključki: Dobljeni podatki kažejo, da mišica BF z leti in s sedečim načinom življenja postaja počasnejša in manj tonizirana. Na osnovi pridobljenih TMG podatkov se lahko oceni mišična neravnovesja v človeškem telesu in rezultate se lahko interpretira tudi v okviru klinične pomembnosti.

Ključne besede: tenziomiografija, biceps femoris, življenjski slog, staranje, šport

INTRODUCTION

The world's population is aging, and the proportion of elderly people keeps increasing. In 2010, the proportion of people aged over 65 years accounted for about 8 % of the world's population. The forecast for 2050 projects that the percentage will increase to 16 %, which will represent some 1.5 billion people (2010 Revision of the World Population Prospects).

According to the Statistical Office of the Republic of Slovenia (2015), which summarizes Eurostat's data projections, it is expected that in the year 2060 a third of Slovenians will be aged over 65 years. In 2015, the proportion of Slovenians older than 65 amounted to 20 %, whereas it is estimated that this will increase to 30 % in 2060. Longer life spans as well as larger proportions of elderly population will likely lead to an increase in the number of diseases that are more prevalent with age.

It is clear that physical inactivity significantly contributes to mortality, as the WHO (2013) reported that over 3.2 million people die each year due to physical inactivity. Many non-communicable chronic health conditions, prevailing in developed and developing countries are associated with physical inactivity (Blair, Sallis, Hutber, & Archer, 2012; Chodzko-Zajko et al., 2009; Paterson, Jones, & Rice, 2007).

In addition to the higher incidence of these risk factors with aging, a decline in many physiological systems occurs along with the loss of muscle mass, impaired balance, reductions of muscle strength and endurance (Sakuma & Yamaguchi, 2012) as well as cognitive capacities, all of which impacts functional independence (Salthouse, 2003).

There are various guidelines for physical activity of people aged 65 years and above: (i) The WHO's recommends (WHO, 2010) at least 150 minutes of moderate-intensity aerobic physical activity per week, or at least 75 minutes of high intensity physical activity per week, or an equivalent combination of moderate and high intensity exercise; (ii) The American College of Sport Medicine (ACSM) and the American Heart Association (AHA) recommend 30 minutes of moderate intensity aerobic physical activity 5 times per week, or 20 minutes of high intensity physical activity 3 times per week, or an equivalent combination of moderate and high intensity exercise with a duration of at least 10 minute bouts is recommended (Nelson et al., 2007). While WHO is not specific, the ACSM and the AHA emphasize that it is also necessary to incorporate strength training twice per week, which should be composed of 8 to 10 exercises with 10 to 15 repetitions and 1 to 2 sets.

Šimunič, Pišot, & Rittweger (2009) investigated the age and sport activity type on postural (VL, vastus lateralis) and non-postural (BF, biceps femoris) muscle contraction time in master athletes and non-athletes. Authors performed Tensiomyographic (TMG) assessment of 35+ years of control group, explosive athletes and endurance athletes. They found that the sport activity type significantly affects contraction time (Tc) only in non-postural BF muscle. BF muscle deteriorates in all groups, but least in explosive athletes, which emphasizes strength and power training to maintain skeletal muscle contractile properties. They explained that postural muscles receive enough daily stimuli to be prevented from major deterioration. Although they reported Tc data, they failed to report maximal displacement of TMG response (Dm).

Therefore, we decided to obtain TMG responses and calculate Tc and Dm of BF in 3 age groups and 2 fitness groups. We decided to measure BF as, according to Valenčič & Djordjevič (2002) in Djordjevič, Rozman, & Pišot (2005), there are indications that BF muscle is one of the most sensitive to deterioration or improvement after physical inactivity or age and training, respectively.

METHODS

Participants

Ninety male participants were divided into 3 age groups and measured in the *laboratory* of the Institute for *Kinesiology Research* in Koper, using TMG: young adults (YA), middle-aged adults (MA), and older adults (OA). The selection of participants was based on the following criteria: 15 YA (age: 23.7 ± 4.3 years; body height: 172 ± 8.0 cm; body mass: 59 ± 10.5 kg), 15 MA (age: 46.6 ± 5.6 years; body height: 182 ± 6.7 cm; body mass: 88 ± 7.0 kg), and 15 OA (age: 64.2 ± 6.5 years; body height: 175 ± 2.6 cm; body mass: 87 ± 5.0 kg). In each group, half of the participants were active 2 to 3 times in organized sport activities, while 15 were not.

Tensiomyography

Two contractile parameters, Dm and Tc of BF muscle were measured in ninety males by TMG (TMG – BMC, Ljubljana, Slovenia). The measurement point in BF muscle was defined at the midpoint of the line between the fibula head and the ischial tuberosity. Positioning the sensor directly on the skin above the muscle belly makes the method sensitive to mechanical displacement of the underlying muscle tissue. The measurements were performed isometrically in relaxed predefined position with fixed joint angle at 5 degrees knee flexion, with the participants lying on their front. Self-adhesive electrodes were placed directly on the muscle belly: the cathode was placed 5 centimetres distally, while the anode was 5 centimetres proximally from the measurement point. The amplitude of the electrical stimulation was gradually increased to get maximal response. From the twitch response, the Dm was analysed in mm and Tc was calculated in ms as time of the response reaching from 10 % to 90 % of the maximal amplitude.

Statistics

All data are presented with mean values ($\pm$ SD). After checking for normality of distribution with visual inspection, we proceeded with 3×2 analysis of variance with post hoc t-tests for independent samples and using Bonferroni corrections. All decisions were accepted with alpha set at 0.05.

RESULTS

In Table 1 we found shortest Tc in active YA that is increasing with age ($P = 0.003$) and lifestyle groups ($P = 0.041$). Dm was found to be higher in active YA than in se-

dentary YA ($P = 0.031$). Post hoc analysis revealed also shorter T_c in active YA than in sedentary YA ($P = 0.001$). Active YA had also shorter T_c than active OA ($P = 0.046$). Active YA had also lower D_m than sedentary YA ($P = 0.031$), while pooled YA has trend towards lower D_m than pooled MA ($P = 0.073$) and pooled OA ($P = 0.120$).

Table I: Comparison between active / sedentary participants of three age groups in BF contraction time and maximal displacement.

Age group	Lifestyle group	Contraction time (ms)	Displacement (mm)
Young adults	Active	26.2 ± 10.2	5.5 ± 1.1
	Sedentary	49.0 ± 11.7	8.8 ± 4.3
Middle-age adults	Active	35.2 ± 16.4	6.4 ± 2.1
	Sedentary	42.8 ± 17.2	6.4 ± 2.5
Older adults	Active	33.6 ± 4.6	6.0 ± 2.5
	Sedentary	37.8 ± 7.1	5.9 ± 1.1

DISCUSSION

It is well established that aging leads to progressive changes in the human body, which causes a loss of muscle function, weakness, disease and death. Older people are also the most sedentary and physically inactive segment of society, according to certain evidence (Paterson & Warburton, 2010), therefore, it is hard to study the aging effect solely, independently of physical activity or fitness level. Therefore, it is important to study different age groups but levelled on physical or sport activity.

There are differences in skeletal muscles between physically active and inactive people, as evident in muscle composition analysis conducted with TMG. This method enables easy as well as selective measurements of contractile properties of the muscle belly and was recently shown to be a valid, repeatable and non-invasive assessment of muscle composition (Šimunič et al., 2011; Šimunič, 2012; Šimunič, 2015).

Comparison of D_m between active / sedentary participants

The biggest differences are between active and sedentary YA. YA have expectedly lowest D_m , which indicates the highest BF tone. Pišot et al. (2008) provided evidence that D_m reflects physical activity or inactivity and demonstrated that D_m increases after acute muscle atrophy. There were no differences in D_m regarding the lifestyle between

MA and OA. Pišot et al. (2008) further explained that the smaller the Dm value before bed rest, the larger the change induced by bed rest, which puts TMG amplitude Dm as a measure of muscle belly stiffness.

Comparison of Tc between active / sedentary participants

Shortest Tc was in active YA and was getting higher with age and sedentary lifestyle. Tc reflects muscle composition, whereas shorter Tc indicates lower proportion of myosin heavy chain type 1 (Šimunič et al., 2011). Šimunič, Pišot, Rittweger, and Mekjavić (2008) found that BF muscle deteriorates in much greater scale than VL with age and sport group and they evaluated this with Tc calculated from mechanical response of muscle belly, using TMG.

The data obtained highlighted the importance of physical / sports activity and the importance of TMG as method of evaluating muscles status and as method for monitoring the effects of PA on the physical fitness of people.

Based on the data obtained it would be possible to choose the most optimal training method and the means to plan and modify the physical preparation of the individual or of homogenous groups and such adjusted physical / sporting activity can improve their physical condition. It consequently improves physical health of people and especially in elderly it contributes to increased stability, autonomy, mobility, self-confidence when moving, which has a great impact on both well-being and satisfaction of older adults.

It is well known that regular physical activity and exercise are beneficial for physical and mental health. Hence, it is important that people consider this already in their younger age and educate themselves about the positive effects of being active, the importance of maintaining motor abilities as well as the value of quality of life in older age.

Without data on movement, physical, physiological and biochemical characteristics, it is difficult to accurately design, programme and model exercise, adapted to the needs of individuals of a certain age and capacity.

CONCLUSION

In conclusion, Tc and Dm were found to be sensitive of age and fitness level in our participants. That makes TMG useful for a variety of purposes. Since TMG data correlates to muscle composition and muscle atrophy, it makes TMG useful in the field of aging, preventive assessment, sport training, rehabilitation, etc.

REFERENCES

- Blair, S., Sallis, R., Hutber, A., & Archer, E. (2012). Exercise therapy - the public health message. *Scandinavian journal of medicine & science in sports*, 22(4), e24–e28. doi: 10.1111/j.1600-0838.2012.01462.x [VIEW ITEM](#)
- Chodzko-Zajko, W. J., Proctor, D., Fiatarone Singh, M. A., Minson, C. T., Nigg, C. R., Salem, G. J. et al. (2009). Exercise and physical activity for older adults. American College of Sports Medicine position stand. *Medicine and science in sports and exercise*, 41(7), 1510–1530. doi: 10.1249/MSS.0b013e3181a0c95c [VIEW ITEM](#)
- Nelson, M. E. et al. (2007). Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine and science in sports and exercise*, 39(8), 1435–1445. doi: 10.1249/mss.0b013e3180616aa2 [VIEW ITEM](#)
- Paterson, D., Jones, G., & Rice, C. (2007). Ageing and physical activity: evidence to develop exercise recommendations for older adults. *Applied physiology, nutrition, and metabolism*, 32(Suppl. 2E), S69–S108. [VIEW ITEM](#)
- Paterson, D. H., & Warburton, D. E. (2010). Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. *The international journal of behavioral nutrition and physical activity*, 7(38), 1–22. doi: 10.1186/1479-5868-7-38. [VIEW ITEM](#)
- Pišot, R., Narici, M. V., Šimunic, B., De Boer, M., Seynnes, O., Jurdana, M., ... Mekjavić, I. B. (2008). Whole muscle contractile parameters and thickness loss during 35-day bed rest. *European journal of applied physiology*, 104(2), 409–414. doi: 10.1007/s00421-008-0698-6 [VIEW ITEM](#)
- Sakuma, K., & Yamaguchi, A. (2012). Sarcopenia and age-related endocrine function. *International journal of endocrinology*, 2012: 127362. doi: 10.1155/2012/127362 [VIEW ITEM](#)
- Salthouse, T. A. (2003). Memory aging from 18 to 80. *Alzheimer disease and associated disorders*, 17(3), 162–167. PMID: 14512830
- Šimunič, B. (2012). Between-day reliability of a method for non-invasive estimation of muscle composition. *Journal of electromyography and kinesiology*, 22(4), 527–530. doi: 10.1016/j.jelekin.2012.04.003 [VIEW ITEM](#)
- Šimunič, B. (2015). Tensiomyography amplitude - a potential non-invasive skeletal muscle pre-frailty parameter. In U. Marušič, B. Šimunič, R. Pišot (Eds.), *Hip fracture in the elderly: reasons, consequences and rehabilitation* (pp. 47–63). Koper: University of Primorska, Scientific and research centre of Koper, Publishing house Annales.
- Šimunič, B., Degens, H., Rittweger, J., Narici, M., Mekjavić, I. B., & Pišot, R. (2011). Noninvasive estimation of myosin heavy chain composition in human skeletal muscle. *Medicine and science in sports and exercise*, 43(9), 1619–1625. doi: 10.1249/MSS.0b013e31821522d0 [VIEW ITEM](#)
- Šimunič, B., Pišot, R., & Rittweger, J. (2009). The effect of ageing on contraction time of postural and non-postural skeletal muscles in master athletes. In M. Mikalački (Ed.), *Proceedings book, 1st International Scientific Conference "Exercise and Quality of Life"*, Novi Sad, Serbia, March 26–28, 2009 (pp. 185–190). Novi Sad: University of Novi Sad, Faculty of Sport and Physical Education. Retrieved from <http://www.eqol.uns.ac.rs/1steqol/2%20elderly/023%20simunic%20pisot%20rittweiler.pdf>

- Šimunič, B., Pišot, R., Rittweger, J. & Mekjavić, I. B. (2008).** Regular sport activity does not prevent skeletal muscle contraction time loss in master athletes. In M. Blahutková (Ed.), Sport a kvalita života 2008 = Sport and quality of life 2006 : sbornik abstrakt mezinárodní konference konané 6.-7. listopadu 2008 v Brně : proceedings of abstracts of International Conference 6th - 7th November 2008 in Brno (p. 154). Brno: Masarykova univerzita, Fakulta sportovních.
- Statistical Office of the Republic of Slovenia (2015).** International day of older persons. Retrieved from <http://www.stat.si/StatWeb/en/News/Index/5477>
- United Nations, Department of Economic and Social Affairs, Population Division (2011).** World population prospects: the 2010 revision, Volume I: Comprehensive tables. Retrieved from: http://www.un.org/en/development/desa/population/publications/pdf/trends/WPP2010/WPP2010_Volume-I_Comprehensive-Tables.pdf
- Valenčič, V. & Djordjević, S. (2002).** Maximal velocity and biceps femoris muscle contraction time dependence - tensiomyographic analysis in elite sprinters. Salzburg: European College of Sport Science (ECSS). In Djordjević S., Rozman, S. & Pišot, R. (2005). Monitoring of biceps femoris (BF) activation pattern changes between maximal and supramaximal sprints. Book of Abstracts of the 10th Annual Congress of the European College of Sport Science in Belgrade, Serbia from 13-16 July 2005.
- WHO - World Health Organisation (2010).** Global recommendations on physical activity for health. ISBN 978-92-4-159-997-9. Retrieved from <http://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf>
- WHO - World Health Organisation (2013).** Global strategy on diet, physical activity and health. Retrieved from http://www.who.int/dietphysicalactivity/factsheet_inactivity/en/index.html

EXERCISE AND THE AGEING IMMUNE SYSTEM

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ABSTRACT

Life expectancy in the developed world has increased exponentially over the last century. There is now a strong body of evidence demonstrating that aging is accompanied by severe alterations in the immune system, a process known as “immunosenescence”, commonly defined as the functional decline of the adaptive immune system with age. Inflamm-aging, a chronic progressive increase in the inflammatory status has attracted great attention in recent years in age-related research field. This process plays an important role in the age-related diseases, such as heart disease, atherosclerosis, Alzheimer’s disease, type II diabetes, among others. Exercise impacts immune function both acutely and chronically. This article describes how exercise activates the release of hormones, myokines and cytokines, as well as modulates the expression of various immune-reactive molecules, which all contribute to anti-inflammatory effects and possible attenuation of immunosenescence.

Keywords: immunosenescence, inflamm-aging, exercise

GIBANJE IN IMUNSKI SISTEM MED PROCESOM STARANJA

IZVLEČEK

V zadnjem stoletju je pričakovana življenjska doba v zahodnem svetu eksponentno narasla. Staranje spremljajo velike spremembe v imunskem sistemu. Ta proces, ime-

novan imunosenescenca, je definiran kot funkcionalni upad adaptivnega imunskega sistema s staranjem. Za staranje je značilno tudi progresivno naraščanje vnetja, ki ima pomembno vlogo pri s staranjem povezanih boleznih, kot so bolezni srca, ateroskleroza, Alzheimerjeva bolezen, sladkorna bolezen tipa 2 in druge. Gibanje vpliva na imunski sistem tako akutno kot kronično. Gibanje povzroči sproščanje hormonov, miokinov in citokinov in spremeni ekspresijo različnih z imunostjo povezanih molekul, kar vpliva na protivnetne učinke in zmanjšanje imunosenescence, kar opisuje članek.

Ključne besede: imunosenescenca, s staranjem povezano kronično vnetje, gibanje

INTRODUCTION

Life expectancy in the developed world has increased exponentially over the last century. There is now a strong body of evidence demonstrating that aging is accompanied by severe alterations in the immune system, a process known as “immunosenescence”, commonly defined as the functional decline of the adaptive immune system with age. Indeed, according to Arnold et al. (2011), the assurance of longevity and healthy aging occurs by maintaining the integrity of immunity. The worldwide increase of the proportion of people older than 65 years has led to the rising costs of age-related diseases; therefore, a better understanding of immunosenescence could help us to limit the development and progression of age-related diseases.

Immunosenescence results from the accumulation of molecular and cellular defects due to thymic involution (the age-related reduction in thymus size and activity), oxidative damage, and hyper stimulation of both the innate and adaptive immune system. Thymic involution results in significant exhaustion of naive T cells, and the shrinkage of the T-cell repertoire (Nguyen, Mendelsohn, & Larrick, 2017). Moreover, the progressive functional B lymphocyte deficits have also been suggested as the main responsible factors for age-associated disorders (Gruver, Hudson, & Sempowski 2007). However, in general, all immune cells are affected by aging, but the adaptive response seems to be more affected by the age-related changes in the immune system (Franceschi, Bonafè, & Valensin, 2000). Poor immune function in elderly combined with continued exposure to antigens, results in chronic activation of macrophages and other pro-inflammatory cells and contributes to chronic low-level systemic inflammation common in older age (Franceschi et al., 2000).

INFLAMMATION, OXIDATIVE STRESS AND AGING

Chronic low-grade systemic inflammation is a common manifestation of aging. While acute inflammation is normally tightly controlled and is a part of the common physiological healing processes, low-grade systemic inflammation describes a chronic,

mostly asymptomatic, low-grade inflammatory state that can eventually lead to chronic illness in the elderly such as cardiovascular diseases (CVD), diabetes, osteoarthritis, obesity, physical disability, Alzheimer's disease (AD), sarcopenia, among others (Singh & Newman, 2011). But, as with all other physiological systems, with aging there are also significant declines in the immune function that promote inflammation (Chung et al., 2009). Age-related chronic inflammation is often attributed to the immune system (Franceschi et al., 2000; Vasto et al., 2007), because as we age, we accumulate an "antigenic burden," the sum of all the antigenic stresses (both internal and external) that we unavoidably encounter throughout life, which causes the progressive activation of macrophages and other immune-cell types. This low-level chronic activation leads to the continuous production of inflammatory factors such as cytokines and chemokines, which raises the basal levels of these factors throughout the body. This process, termed "inflamm-aging" has been thoroughly described elsewhere and is supported by a substantial body of data (Franceschi et al., 2000; Singh & Newman, 2011). Indeed, 2-4 fold increase in the primarily serum levels of pro-inflammatory cytokines such as interleukine-7 (IL-7), IL-6, tumor necrosis factor- α (TNF- α) and acute phase proteins such as C-reactive protein (CRP) are typical for aged individuals when compared to younger individuals, even in the absence of chronic diseases (Bruunsgaard, 2006; Vasto et al., 2007; Xia et al., 2016). Thus, circulating levels of inflammatory mediators such as IL-6 and CRP have been found to be useful prognostic markers in very old people (Jylhä et al., 2007; Singh & Newman, 2011). Indeed, elevated levels of IL-6 and TNF- α in the serum of elderly have been found to be associated with some diseases (De Martinis, Franceschi, Monti, & Ginaldi, 2005). IL-6 is a pro- and anti-inflammatory cytokine produced by the cells of the immune system, vascular endothelial cells, adipocytes, and skeletal muscles. Another cytokine, TNF- α is produced mainly by macrophages, but also by vascular endothelial cells, adipocytes, and some others, and has been shown to increase muscle protein degradation and impair muscle protein synthesis. Its elevated levels have been observed in many inflammatory diseases, such as osteoarthritis, rheumatoid arthritis, systemic lupus erythematosus, idiopathic inflammatory myopathies, metabolic syndrome, type 2 diabetes mellitus and congestive heart failure (Thomas, 2013). CRP is an acute phase protein produced by the liver and its levels are up-regulated in response to elevation in IL-6 (Singh & Newman, 2011). The exact mechanism for the increase in pro-inflammatory cytokines with age is still not fully understood.

Accumulating evidence indicates that obesity and systemic inflammation are highly interrelated. Obesity is associated with diabetes and CVD as well as growing number of other diseases with inflammatory components including dementia and cancer (Knight, 2011). Adipose tissue (AT) acts as an endocrine organ by releasing some pro- and anti-inflammatory cytokines, which originate from adipose cells and/or infiltrated macrophages (Ouchi, Parker, Lugus, & Walsh, 2011). AT is infiltrated with macrophages in two separate polarization states: M1, which produce pro-inflammatory cytokines and M2, producing anti-inflammatory cytokines. Therefore, it has been proposed that in AT a phenotypic switch takes place toward macrophages of the M1-phenotype, promoting the inflammatory state (reviewed in Müller & Pawelec, 2014).

Moreover, increases in oxidative stress with aging may also contribute to the development of chronic inflammation and disease (Cannizzo et al., 2011). There are several potential mechanisms linking oxidative stress to inflammation (Xia et al., 2016). Aging is associated with increases in both tissue and circulating levels of reactive oxygen species (ROS) as well as a decline in antioxidant capacity (Kregel & Zhang, 2007). To protect itself, organisms have developed various antioxidative defenses that include superoxide dismutase (SOD), glutathione (GSH) peroxidase, and catalase, as well as non-enzymatic ROS scavengers, vitamin E, vitamin C, and uric acid (Lykkesfeldt, Hagen, Vinarsky, & Ames, 1998). Among all this, GSH is the most abundant and effective biological anti-oxidative reductant (Cross et al., 1997). ROS cause both oxidative damage and elicit release of additional “inflamm-aging-cytokines” perpetuating a vicious cycle. Recently, it has been shown that ROS activation of toll-like receptors on a variety of immune cells play an important role in activating the inflammatory cascade (Gill, Tsung, & Billiar, 2010). Therefore, the continual presence of circulating pro-inflammatory factors may keep the immune system in a state of chronic low-level activation and eventually this chronic immune activation causes immunosenescence.

Moreover, low-grade chronic inflammation has also been related to frailty, defined as an increased vulnerability to stress in old age (Hubbard, O'Mahony, Savva, Calver, & Woodhouse, 2009). Frailty results from the accumulation of functional declines in multiple systems that decrease overall physiological reserve leading to weight loss, especially loss of muscle, reduced strength and endurance, and overall poor physical function (Fried et al., 2001). Sarcopenia, one of the most noticeable changes occurring in elderly, is defined as the age-related loss of muscle mass, strength and function and is a major component of frailty and a risk factor for disability outcomes (Lang et al., 2010). It has been shown by Visser et al. (2002) that older people with high cytokine levels (IL-6 and TNF- α) have a tendency to develop sarcopenia (Visser et al., 2002). In addition, a growing body of literature indicates that inflammatory processes are also related to cognitive decline and the development of dementia, including the vascular and Alzheimer's types (Yaffe et al., 2003; Engelhart et al., 2004).

ACUTE EFFECTS OF EXERCISE

As aging is an inevitable process, there is a lot of interest in certain strategies that would reduce age-related inflammation and may therefore improve the quality of life in older adults. As such, there has been recent interest in the manipulation of certain lifestyle factors like increasing physical activity levels, as a way of moderating the effects of aging on the immune system. Regular exercise is recommended for older people for a variety of reasons including increasing muscle mass and reducing risk for chronic diseases of the heart and metabolic systems.

Acutely, exercise induces local and systemic cytokine responses in skeletal muscle. Effects of different types of exercise and different intensities on inflammation in inflammatory conditions were reviewed by Thomas (2013). Eccentric exercise causes

greater muscle damage than concentric and seems to be associated with higher interleukine-6 expression, higher serum creatine kinase and greater recruitment of monocytes, dendritic cells, and memory T cells to sites of infection and injury, although results vary due to differences in the participants' training status, exercise protocols and sampling times. Furthermore, exercise intensity governs the amount of the inflammatory response that follows the exercise bout: while strenuous high-intensity exercise increases TNF- α level, low intensity exercise, if sustained over time, decreases TNF- α level (Thomas, 2013). In a study of acute effect of walking for four consecutive days at a self-selected pace for 30 km a day in twenty octogenarians, changes in immune cell numbers and functions were observed with an emphasis on response of CD4+ T cells, rather than CD8+ T cells or NK cells (van der Geest et al., 2017), with naïve CD4+ subsets dominating the CD4+ T cell compartment.

IMPACT OF CHRONIC PHYSICAL ACTIVITY ON INFLAMMATORY AND OXIDATIVE STATUS

It has been shown that lifelong physical activity is associated with increased lifespan, lower risk of functional and cognitive impairment, and lower levels of inflammatory markers in older adults (Simpson & Guy, 2010). Exercise has also been reported to favorably impact immune function (Simpson & Guy, 2010). Repeated bouts of exercise seem to have a protective effect on the inflammatory response in patients with inflammatory conditions, which might have an important role in skeletal muscle adaptation (Thomas, 2013). Therefore, reducing inflamm-aging via exercise could be an efficient therapeutic approach to either prevent or delay the onset of those chronic diseases associated with low-grade chronic inflammation and thus reduce frailty and mortality in the elderly.

Some cross sectional studies have shown an association between low-grade inflammation and physical inactivity in healthy older subjects (Pedersen & Bruusgaard, 2003; Colbert et al., 2004). In our study of complete inactivity, we observed increased inflammation after 14 days of bed rest (Jurdana et al., 2015). The inflammatory response differed between elderly and young subjects: the elderly group responded to 14-days complete inactivity by pronounced increases in IL-6 and TNF- α while for the young subjects the TNF- α levels did not change and IL-6 levels decreased. Moreover, regular exercise training has been shown to reduce circulating levels of TNF- α , IL-6, and CRP in a population of healthy older adults (Colbert et al., 2004; Nicklas et al., 2008; Phillips, Flynn, McFarlin, Stewart, & Timmerman, 2010; Woods, Wilund, Martin, & Kistler, 2012).

The exact mechanism for reducing the levels of inflammatory markers by physical activity is not clear, but some possible mechanisms have been proposed for the anti-inflammatory effects of exercise (Gleeson et al., 2011). The anti-inflammatory effects of regular exercise may be mediated via reduction in visceral fat mass. Regular exercise reduces fat mass and AT inflammation, both known to contribute to systemic inflamma-

tion (Calder et al., 2011). Independently of losses of fat mass, exercise also increases muscle production of IL-6. In contrast to what occurs in sepsis, contracting muscle produces IL-6 independently of TNF- α (there is, in fact, no TNF- α increase during exercise), which suggests the cytokine cascades in the contracting muscle are markedly different from those during infection (Pedersen & Febbraio, 2008). Exercise derived IL-6 is considered to possess a central role in anti-inflammatory activities and to be responsible for reducing TNF- α production – and increase anti-inflammatory cytokines, as for example anti-inflammatory adiponectin (Starkie, Ostrowski, Jauffred, Febbraio, & Pedersen, 2003). In addition, the anti-inflammatory effects of regular exercise may be mediated via increased production and release of anti-inflammatory cytokines, or reduced expression of toll-like receptors on monocytes and macrophages (Gleeson et al., 2011; Singh & Newman, 2011). Moreover, increases in antioxidant capabilities with regular exercise may prevent cellular DNA and structural damage from attacking ROS thus preventing premature biological aging of specific immune cells (Mota et al., 2010). For example, it has been shown that proper physical exercise blunts the age-related decrease of GSH the body's major anti-oxidative reductant (Carter et al., 2007).

As mentioned above, AD is also associated with chronic low-grade inflammation. Physical activity influences inflammation, and both affect brain structure and AD. Indeed, higher levels of physical activity have been associated with a lower risk of developing AD (Luck et al., 2013). Although the main mechanism for this reduced risk is still unclear, physical activity may be associated with lower brain amyloid levels in humans (Liang et al., 2010; Head et al., 2012; Brown et al., 2013). Further, while imaging techniques in humans showed that exercise positively correlated with brain-derived neurotrophic factor (a marker of adult neurogenesis), spatial memory, and various cognitive functions (Voss, Vivar, Kramer, & van Praag, 2013), enhanced neurogenesis due to exercise was directly shown in rodent studies (Voss et al., 2013).

Although it is possible that exercise as part of lifestyle acts to prevent or treat immunosenescence, there is no clear answer to this question thus far. However, several interventions, including different types of exercises, have been proposed to restore immune function in elderly people. It has been shown that moderate exercise training might up-regulate monocytes and dendritic cells, thereby possibly improving T-cell mediated immunity in elderly (Shimizu et al., 2008; Shimizu et al., 2011). Moreover, it has been shown, that regular exercise is associated with improved immune responsiveness to influenza vaccination in elderly (Kohut & Senchina, 2004; Woods et al., 2009). Thus, the accumulated data thus far suggest that exercise may be a powerful approach to restoring immune function in elderly people.

CONCLUSIONS

Taken together, we conclude that physical activity, such as regular exercise, activates the release of hormones, myokines and cytokines, as well as modulates the expression of various immune-reactive molecules, which all contribute to anti-inflammatory

effects and possible the attenuation of immunosenescence. Moreover, the reduction of visceral fat mass alone already leads to a decreased production and release of pro-inflammatory adipokines from fat tissue. Therefore, lifestyle attitudes, particularly aerobic exercise in the elderly may provide low cost and long-term ways to limit inflammation and slow declines in the elderly.

REFERENCES

- Arnold, C. R., Wolf, J., Brunner, S., Herndler-Brandstetter, D., & Grubeck-Loebenstein, B. (2011).** Gain and loss of T cell subsets in old age--age-related reshaping of the T cell repertoire. *Journal of Clinical Immunology*, 31(2), 137-146. doi 10.1007/s10875-010-9499-x. [VIEW ITEM](#)
- Brown, B. M., Peiffer, J. J., Taddei, K., Lui, J. K., Laws, S. M., Gupta, V. B., ... Martins, R. N. (2013).** Physical activity and amyloid- β plasma and brain levels: results from the Australian Imaging, Biomarkers and Lifestyle Study of Ageing. *Molecular Psychiatry*, 18(8), 875-881. doi:10.1038/mp.2012.107. [VIEW ITEM](#)
- Brunnsgaard, H. (2006).** The clinical impact of systemic low-level inflammation in elderly populations. With special reference to cardiovascular disease, dementia and mortality. *Danish Medical Bulletin*, 53(3), 285-309.
- Calder, P. C., Ahluwalia, N., Brouns, F., Buetler, T., Clement, K., Cunningham, K., ... Winklhofer-Roob, B. M. (2011).** Dietary factors and low-grade inflammation in relation to overweight and obesity. *British Journal of Nutrition*, 106(3), S5-S78. doi: 10.1017/S0007114511005460. [VIEW ITEM](#)
- Cannizzo, E. S., Clement, C. C., Sahu, R., Follo, C., & Santambrogio, L. (2011).** Oxidative stress, inflamm-aging and immunosenescence. *Journal of Proteomics*, 74(11), 2313-2323. doi: 10.1016/j.jprot.2011.06.005. [VIEW ITEM](#)
- Carter, C. S., Hofer, T., Seo, A. Y., & Leeuwenburgh, C. (2007).** Molecular mechanisms of life- and health-span extension: role of calorie restriction and exercise intervention. *Applied Physiology, Nutrition and Metabolism*, 32(5), 954-966. doi: 10.1139/H07-085. [VIEW ITEM](#)
- Chung, H. Y., Cesari, M., Anton, S., Marzetti, E., Giovannini, S., Seo, A. Y., ... Leeuwenburgh, C. (2009).** Molecular inflammation: underpinnings of aging and age-related diseases. *Ageing Research Reviews*, 8(1), 18-30. doi: 10.1016/j.arr.2008.07.002. [VIEW ITEM](#)
- Colbert, L. H., Visser, M., Simonsick, E. M., Tracy, R. P., Newman, A. B., Kritchevsky, S. B., ... Harris, T. B. (2004).** Physical activity, exercise, and inflammatory markers in older adults: findings from the Health, Aging and Body Composition Study. *Journal of the American Geriatric Society*, 52(7), 1098-1104. doi: 10.1111/j.1532-5415.2004.52307.x. [VIEW ITEM](#)
- Cross, C. E., Hasegawa, G., Reddy, K. A., & Omaye, S. T. (1977).** Enhanced lung toxicity of O₂ in selenium-deficient rats. *Research Communications in Chemical Pathology and Pharmacology*, 16(4), 695-706.
- De Martinis, M., Franceschi, C., Monti, D., & Ginaldi, L. (2005).** Inflamm-aging and lifelong antigenic load as major determinants of ageing rate and longevity. *FEBS Letters*, 579(10), 2035-2039. doi: 10.1016/j.febslet.2005.02.055. [VIEW ITEM](#)

- Engelhart, M. J., Geerlings, M. I., Meijer, J., Kiliaan, A., Ruitenberg, A., van Swieten, J. C., ... Breteler, M. M. B. (2004). Inflammatory proteins in plasma and the risk of dementia: the rotterdam study. *Archives of Neurology*, 61(5), 668-672. doi:10.1001/archneur.61.5.668. [VIEW ITEM](#)
- Franceschi, C., Bonafè, M., & Valensin, S. (2000). Human immunosenescence: the prevailing of innate immunity, the failing of clonotypic immunity, and the filling of immunological space. *Vaccine*, 18(16), 1717-1720. doi: 10.1016/S0264-410X(99)00513-7. [VIEW ITEM](#)
- Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., ... McBurnie, M. A. (2001). Frailty in older adults: evidence for a phenotype. *The journals of gerontology. Series A, Biological sciences and medical sciences*, 56(3), M146-m157. doi: 10.1093/gerona/56.3.M146. [VIEW ITEM](#)
- Gill, R., Tsung, A., & Billiar, T. (2010). Linking oxidative stress to inflammation: Toll-like receptors. *Free Radical Biology and Medicine*, 48(9), 1121-1132. doi: 10.1016/j.freeradbiomed.2010.01.006. [VIEW ITEM](#)
- Gleeson, M., Bishop, N. C., Stensel, D. J., Lindley, M. R., Mastana, S. S., & Nimmo, M. A. (2011). The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. *Nature Reviews Immunology*, 11(9), 607-615. doi:10.1038/nri3041. [VIEW ITEM](#)
- Gruver, A. L., Hudson, L. L., & Sempowski, G. D. (2007). Immunosenescence of ageing. *The Journal of Pathology*, 211(2), 144-156. doi: 10.1002/path.2104. [VIEW ITEM](#)
- Head, D., Bugg, J. M., Goate, A. M., Fagan, A. M., Mintun, M. A., Benzinger, T., ... Morris, J. C. (2012). Exercise engagement as a moderator of the effects of APOE genotype on amyloid deposition. *Archives of Neurology*, 69(5), 636-643. doi:10.1001/archneur.2011.845. [VIEW ITEM](#)
- Hubbard, R. E., O'Mahony, M. S., Savva, G. M., Calver, B. L., & Woodhouse, K. W. (2009). Inflammation and frailty measures in older people. *Journal of Cellular and Molecular Medicine*, 13(9B), 3103-3109. doi: 10.1111/j.1582-4934.2009.00733.x. [VIEW ITEM](#)
- Jurdana, M., Jenko-Pražnikar, Z., Mohorko, N., Petelin, A., Jakus, T., Šimunič, B., Pišot, R. (2015). Impact of 14-day bed rest on serum adipokines and low-grade inflammation in younger and older adults. *Age*, 37(6), 116. doi: 10.1007/s11357-015-9848-z. [VIEW ITEM](#)
- Jylhä, M., Paavilainen, P., Lehtimäki, T., Goebeler, S., Karhunen, P. J., Hervonen, A., & Hurme, M. (2007). Interleukin-1 receptor antagonist, interleukin-6, and C-reactive protein as predictors of mortality in nonagenarians: the vitality 90+ study. *The journals of gerontology. Series A, Biological sciences and medical sciences*, 62(9), 1016-1021. doi: 10.1093/gerona/62.9.1016. [VIEW ITEM](#)
- Knight, J. A. (2011). Diseases and disorders associated with excess body weight. *Annals of Clinical & Laboratory Science*, 41(2), 107-121. [VIEW ITEM](#)
- Kohut, M. L., & Senchina, D. S. (2004). Reversing age-associated immunosenescence via exercise. *Exercise Immunology Review*, 10, 6-41.
- Kregel, K. C., & Zhang, H. J. (2007). An integrated view of oxidative stress in aging: basic mechanisms, functional effects, and pathological considerations. *American Journal of Physiology, Regulatory, Integrative and Comparative Physiology*, 292(1), R18-R36. doi: 10.1152/ajpregu.00327.2006. [VIEW ITEM](#)

- Lang, T., Streeper, T., Cawthon, P., Baldwin, K., Taaffe, D. R., & Harris, T. B. (2010).** Sarcopenia: etiology, clinical consequences, intervention, and assessment. *Osteoporosis International*, 21(4), 543-559. doi: 10.1007/s00198-009-1059-y. [VIEW ITEM](#)
- Liang, K. Y., Mintun, M. A., Fagan, A. M., Goate, A. M., Bugg, J. M., Holtzman, D. M., ... Head, D. (2010).** Exercise and Alzheimer's disease biomarkers in cognitively normal older adults. *Annals of Neurology*, 68(3), 311-318. doi: 10.1002/ana.22096. [VIEW ITEM](#)
- Luck, T., Riedel-Heller, S. G., Lupp, M., Wiese, B., Köhler, M., Jessen, F., ... Maier, W. (2013).** Apolipoprotein E epsilon 4 genotype and a physically active lifestyle in late life: analysis of gene-environment interaction for the risk of dementia and Alzheimer's disease dementia. *Psychological Medicine*, 44(6), 1319-1329. doi: 10.1017/S0033291713001918. [VIEW ITEM](#)
- Lykkesfeldt, J., Hagen, T. M., Vinarsky, V., & Ames, B. N. (1998).** Age-associated decline in ascorbic acid concentration, recycling, and biosynthesis in rat hepatocytes--reversal with (R)-alpha-lipoic acid supplementation. *FASEB Journal*, 12(12), 1183-1189. [VIEW ITEM](#)
- Mota, M. P., Peixoto, F. M., Soares, J. F., Figueiredo, P. A., Leitão, J. C., Gaivão, I., & Duarte, J. A. (2010).** Influence of aerobic fitness on age-related lymphocyte DNA damage in humans: relationship with mitochondria respiratory chain and hydrogen peroxide production. *Age*, 32(3), 337-346. doi: 10.1007/s11357-010-9138-8. [VIEW ITEM](#)
- Müller, L., & Pawelec, G. (2014).** Aging and immunity - Impact of behavioral intervention. *Brain Behaviour and Immunity*, 39, 8-22. doi: 10.1016/j.bbi.2013.11.015. [VIEW ITEM](#)
- Nguyen, V., Mendelsohn, A., & Larrick, J. W. (2017).** Interleukin-7 and Immunosenescence. *Journal of Immunology Research*, 2017:4807853. doi: 10.1155/2017/4807853. [VIEW ITEM](#)
- Nicklas, B. J., Hsu, F. C., Brinkley, T. J., Church, T., Goodpaster, B. H., Kritchevsky, S. B., & Pahor, M. (2008).** Exercise training and plasma C-reactive protein and interleukin-6 in elderly people. *Journal of the American Geriatric Society*, 56(11), 2045-2052. doi: 10.1111/j.1532-5415.2008.01994.x. [VIEW ITEM](#)
- Ouchi, N., Parker, J. L., Lugus, J. J., & Walsh, K. (2011).** Adipokines in inflammation and metabolic disease. *Nature Reviews Immunology*, 11(2), 85-97. doi:10.1038/nri2921. [VIEW ITEM](#)
- Pedersen, B. K., & Bruunsgaard, H. (2003).** Possible beneficial role of exercise in modulating low-grade inflammation in the elderly. *Scandinavian Journal of Medicine & Science in Sports*, 13(1), 56-62. doi: 10.1034/j.1600-0838.2003.20218.x. [VIEW ITEM](#)
- Pedersen, B. K., & Febbraio, M. A. (2008).** Muscle as an endocrine organ: focus on muscle-derived interleukin-6. *Physiological Review*, 88(4), 1379-1406. doi: 10.1152/physrev.90100.2007. [VIEW ITEM](#)
- Phillips, M. D., Flynn, M. G., McFarlin, B. K., Stewart, L. K., & Timmerman, K. L. (2010).** Resistance training at eight-repetition maximum reduces the inflammatory milieu in elderly women. *Medicine and Science in Sports & Exercise*, 42(2), 314-325. doi: 10.1249/MSS.0b013e3181b11ab7. [VIEW ITEM](#)
- Shimizu, K., Kimura, F., Akimoto, T., Akama, T., Tanabe, K., Nishijima, T., ... Kono, I. (2008).** Effect of moderate exercise training on T-helper cell subpopulations in elderly people. *Exercise Immunology Review*, 14, 24-37.
- Shimizu, K., Suzuki, N., Imai, T., Aizawa, K., Nanba, H., Hanaoka, Y., ... Akama, T. (2011).** Monocyte and T-cell responses to exercise training in elderly subjects.

- The Journal of Strength & Conditioning Research, 25(9), 2565-2572. doi: 10.1519/JSC.0b013e3181fc5e67. [VIEW ITEM](#)
- Simpson, R. J., & Guy, K. (2010).** Coupling aging immunity with a sedentary lifestyle: has the damage already been done? *Gerontology*, 56(5), 449-458. doi: 10.1159/000270905. [VIEW ITEM](#)
- Singh, T., & Newman, A. B. (2011).** Inflammatory markers in population studies of aging. *Ageing Research Reviews*, 10(3), 319-329. doi: 10.1016/j.arr.2010.11.002. [VIEW ITEM](#)
- Starkie, R., Ostrowski, S. R., Jauffred, S., Febbraio, M., & Pedersen, B. K. (2003).** Exercise and IL-6 infusion inhibit endotoxin-induced TNF- α production in humans. *FASEB Journal*, 17(8), 884-886. doi: 10.1096/fj.02-0670fje. [VIEW ITEM](#)
- Thomas, J. L. (2013).** Helpful or harmful? Potential effects of exercise on select inflammatory conditions. *Physician Sportsmed*, 41(4), 93-100. doi: 10.3810/psm.2013.11.2040. [VIEW ITEM](#)
- van der Geest, K. S. M., Wang, Q., Eijsvogels, T. M. H., Koenen, H. J. P., Joosten, I., Brouwer, E., ... Boots, A. M. H. (2017).** Changes in peripheral immune cell numbers and functions in octogenarian walkers - an acute exercise study. *Immunity & ageing*. 14(5). doi: 10.1186/s12979-017-0087-2. [VIEW ITEM](#)
- Vasto, S., Candore, G., Balistreri, C. R., Caruso, M., Colonna-Romano, G., Grimaldi, M. P., ... Caruso, C. (2007).** Inflammatory networks in ageing, age-related diseases and longevity. *Mechanism of Ageing and Development*, 128(1), 83-91. doi: 10.1016/j.mad.2006.11.015. [VIEW ITEM](#)
- Visser, M., Pahor, M., Taaffe, D. R., Goodpaster, B. H., Simonsick, E. M., Newman, A. B., ... Harris, T. B. (2002).** Relationship of interleukin-6 and tumor necrosis factor- α with muscle mass and muscle strength in elderly men and women: the Health ABC Study. *The journals of gerontology. Series A, Biological sciences and medical sciences*, 57(5), M326-332. doi: 10.1093/gerona/57.5.M326. [VIEW ITEM](#)
- Voss, M. W., Vivar, C., Kramer, A. F., & van Praag, H. (2013).** Bridging animal and human models of exercise-induced brain plasticity. *Trends in Cognitive Sciences*, 17(10), 525-544. doi: 10.1016/j.tics.2013.08.001. [VIEW ITEM](#)
- Woods, J. A., Keylock, K. T., Lowder, T., Vieira, V. J., Zerkovich, W., Dumich, S., ... McAuley, E. (2009).** Cardiovascular exercise training extends influenza vaccine seroprotection in sedentary older adults: the immune function intervention trial. *Journal of the American Geriatric Society*, 57(12), 2183-2191. doi: 10.1111/j.1532-5415.2009.02563.x. [VIEW ITEM](#)
- Woods, J. A., Wilund, K. R., Martin, S. A., & Kistler, B. M. (2012).** Exercise, inflammation and aging. *Aging and Disease*, 3(1), 130-140. [VIEW ITEM](#)
- Yaffe, K., Lindquist, K., Penninx, B. W., Simonsick, E. M., Pahor, M., Kritchevsky, S., ... Harris, T. (2003).** Inflammatory markers and cognition in well-functioning African-American and white elders. *Neurology*, 61(1), 76-80. doi: 10.1212/01.WNL.0000073620.42047.D7. [VIEW ITEM](#)
- Xia, S., Zhang, X., Zheng, S., Khanabdali, R., Kalionis, B., Wu, J., ... Tai, X. (2016).** An update on inflamm-aging: mechanisms, prevention, and treatment. *Journal of Immunology Research*, 2016:8426874. doi: 10.1155/2016/8426874. [VIEW ITEM](#)

BENEFITS OF MOTOR AND/OR COGNITIVE EXERCISE: A REVIEW WITH RECOMMENDATIONS FOR THE THIRD AGE

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ABSTRACT

Physical activity in the form of aerobic and resistance exercise, leading to a high level of cardio-respiratory fitness, represents a strong non-pharmacological preventive tool against cognitive decline and thus the occurrence of neuro-degenerative diseases in the third age. However, the effects are even greater if such exercise is performed on regular basis in the form of simultaneous combination of a motor and additional cognitive task, dancing or interactive video dancing or as a body-mind meditative exercise like Tai Ji Quan.

The aim of this article is a review of benefits of motor / cognitive exercise with recommendations for older adults. In the first part, the benefits and effects of physical activity and exercise on cognitive functions are reviewed. Physical activity and exercise have an important role in mitigating age-related structural and behavioural changes within the brain, they increase BDNF levels in the hippocampus, enhance learning and neurogenesis in the hippocampal regions and optimize spatial abilities. The second part is expanded onto the benefits and effects of combined motor and / or cognitive exercise on cognitive functions with recommendations. This combination of motor and / or cognitive exercise could be achieved so that both activities are performed separately, one after another, named "motor and cognitive exercise" or simultaneously, named

“motor-cognitive exercise.” Based on this premise, we divided the second part into three sub-topics: i) the effects of physical exercise / training followed by computerized and other forms of cognitive training, ii) the effects of simultaneously performed motor and cognitive exercise / training and iii) the effects of dancing, interactive video dancing and ancient body-mind meditative techniques. Studies suggest that a combination of mental and physical training may result in greater cognitive gains, namely, in larger improvements in the executive control task and in the paired-associates task.

Keywords: ageing, neurogenesis, motor learning, computerized cognitive training, dancing, body-mind meditative techniques.

PREDNOSTI IN KORISTI GIBALNE IN/ALI KOGNITIVNE VADBE: PREGLED PODROČJA S PRIPOROČILI ZA TRETJE ŽIVLJENJSKO OBDOBJE

IZVLEČEK

Telesna aktivnost v obliki aerobne vadbe in vadbe proti upor, ki omogočata visoko stopnjo kardio-respiratorne pripravljenosti, predstavlja močno nefarmakološko preventivno orodje proti upadu kognitivnih funkcij in s tem pojavljanju nevrodegenerativnih bolezni v tretjem življenjskem obdobju. Učinki vadbe pa so lahko še večji, če se ta izvaja redno v obliki sočasne kombinacije gibalne in dodatne kognitivne naloge, plesa ali interaktivne plesne videoigre ali v obliki meditativne vadbe za telo in um, kot je npr. Tai Ji Quan.

Namen prispevka je pregled prednosti in koristi, ki jih ima gibalna/kognitivna vadba, s priporočili za starejše odrasle osebe. V prvem delu so predstavljene prednosti in koristi ter vplivi telesne aktivnosti in vadbe na kognitivne funkcije. Telesna aktivnost in vadba imata pomembno vlogo pri zmanjševanju s starostjo povezanih strukturnih in vedenjskih sprememb v možganih, hkrati pa vplivata na povečanje BDNF vrednosti v hipokampusu, spodbujata procesa učenja in nevrogeneze in izboljšujeta sposobnosti prostorske predstave. Drugi del prispevka je razširjen na prednosti in koristi ter učinke kombinirane gibalne in/ali kognitivne vadbe na kognitivne funkcije starejših oseb, s priporočili. Kombinacijo gibalne in/ali kognitivne vadbe je mogoče doseči tako, da obe dejavnosti opravljamo ločeno, eno za drugo, kar imenujemo "gibalna in kognitivna vadba/trening" ali pa sočasno, kar smo imenovali "gibalno-kognitivna vadba/trening". Na tej osnovi smo razdelili drugi del na tri podteme: i) učinki telesne vadbe/treninga, ki mu sledijo računalniško podprte in druge oblike kognitivne vadbe/treninga, ii) učinki sočasno opravljene gibalne in kognitivne vadbe/treninga in iii) učinki plesa, interaktivnih plesnih videoiger in meditativnih tehnik na telo in um. Študije poročajo,

da se kombinacija gibalne in kognitivne vadbe odraža v povečanih kognitivnih učinkih, posebno v večjem izboljšanju izvršilnih funkcij.

Ključne besede: staranje, nevrogeneza, hipokampus, računalniško podprta kognitivna vadba, ples, meditativne tehnike za um in telo

INTRODUCTION

Motor abilities, physical, functional and cognitive capacities decrease with ageing. However, with regular and adequate physical and cognitive exercise and training it is possible to reduce or even prevent such declines (Bherer, Erickson & Liu-Ambrose, 2013; Erickson, Gildengers & Butters, 2013; Erickson et al., 2014; Pišot et al., 2016). Health guidelines emphasize that all adults should avoid physical inactivity. According to the guidelines, one's lifestyle should include at least some physical activity in order to obtain health benefits. Physical activity for adults and seniors should include strength, balance and flexibility training, as well as aerobic exercise. The general aim of exercise in late adulthood should be improving the stability and responsiveness of the body, with reduction of the risk of falls as one of the first effects. An appropriate approach in the context of "risk of falls" prevention is the combination of different contents of exercise programs (strength, stability, responsiveness, flexibility etc.). Studies confirm that regular physical activity and high fitness level in the adulthood reduces the risk of negative effects of (primary) ageing as well as those, such as chronic diseases, related to the modern, sedentary lifestyle and environment pollution (secondary ageing) (Bherer, Erickson & Liu-Ambrose, 2013; Chodzko-Zajko et al., 2009; Erickson, Gildengers & Butters, 2013).

The risk of falls increases with age and the falls are the main cause of death associated with injury in the age over 65 years (Rubenstein, 2006). The falls are generally connected with serious consequences such as bone fractures and other injuries. The most common causes of falls are problems with walking and balance (Masud & Morris, 2001). These problems are often associated with neurological and skeletal muscle disorders, impaired ability of thinking, memory and vision as well as different risks in the environment (Richardson & Ashton-Miller, 1996). A sedentary lifestyle and / or lack of physical activity is a common cause, which provoke older people to lose muscle tone and bone mass, reduce their muscle strength and flexibility, which further contributes to increasing the risk of falling. The problem is complex, which can be combined by physiological, biological, behavioural, physical and socio-economic factors (Sattin, 1992).

With ageing, we are also facing difficulties in cognitive functioning, which increases the risk of falls. Of course, being active and exercising regularly cannot stop the biological aging process; however, with proper training we can mitigate or even prevent the age-related cognitive decline. Epidemiological studies suggest that a well-

-functioning cardiovascular system and a high level of physical activity reduce the risk of cognitive decline and dementia in the old age (Gregory, Parker & Thompson, 2012). Aerobic exercise and strength training, but mostly a combination of both, have been shown to improve some cognitive performance measures among previously sedentary older adults. The effects of such exercises on fitness status are largest for the tasks that require complex processing requiring executive control (Chodzko-Zajko et al., 2009).

Motor-cognitive exercise, which is characterized by an additional cognitive (mental) work during the execution of various motor exercises and tasks, can also represent the missing content, and perhaps even more effective upgrade of the usual forms of motor exercise. It has been shown that such exercise contributes to improving the mobility and may prevent falls in older adults (Shatil, 2013). However, the stability and focus of the movement is disrupted in the presence of additional cognitive demand.

The aim of this paper is to describe what are the benefits and effects of motor and / or cognitive exercises on the cognitive function in older adults. Physical activity has favourable effects across numerous physical and mental-health outcomes. It enhances cognitive functioning and it delays age-related cognitive decline which, therefore, results in a better quality of life and health outcomes. The fast developing area of brain-imaging techniques will continue revealing new insides into multiple neural mechanisms that occur at the corticospinal levels and beyond while being physically active per se. However, a growing body of literature in the recent years suggests that the combination of mental and physical training seems to have an additive effect on neurogenesis and it results in even greater increase in neurogenesis than either physical or mental activity alone.

BENEFITS OF PHYSICAL ACTIVITY AND EXERCISE ON COGNITIVE FUNCTION IN OLDER ADULTS

Extensive evidence suggests that physical activity can maintain functional abilities, well-being, and independence in the older person, and it is an essential component of everyday life, and therefore, it is beneficial also for healthy ageing (Netz, Wu, Becker & Tenenbaum, 2005; Penedo & Dahn, 2005; Rejeski & Mihalko, 2001; Gradari, Palle, McGreevy, Fontan-Lozano, & Trejo, 2016). Positive effects of physical activity on cognitive functioning are well reported as well, and are usually presented in two types of studies. The first are (longitudinal) randomized controlled trials that involve intervention and control group(s), and the second are cross-sectional studies that correlate physical activity and exercise levels with cognitive function outcomes and brain structures. The literature overview is summarized in the forthcoming paragraphs with the discussion of possible mechanisms that are most likely to occur.

Ageing process in humans is accompanied by stereotypical structural as well as neurophysiological changes that happen within the brain and variable rates of cognitive decline (Bishop, Lu, & Yankner, 2010). However, this degenerative process was shown to be operational in the older age (Dinse, 2006) and studies showed that physical ac-

tivity and exercise could be one of the lifestyle factors that can successfully moderate age-related cognitive and neurophysiological declines (Hillman, Erickson, & Kramer, 2008; Kramer & Erickson, 2007; Weuve et al., 2004). Kempermann et al. (2010) suggest that there is a need for a proper combination of physical activity and enriched environment for neurogenesis in adult brain. Physical activity and locomotion are believed to stimulate the proliferation of precursor cells in the hippocampus, while enriched environment and learning are needed to promote the survival of immature neurons (Kempermann et al., 2010).

In the animal studies it was shown that physical exercise enhances angiogenesis, synaptogenesis and neurogenesis, and that it regulates several neurotrophic factors (Carro, Nuñez, Busiguina, & Torres-Aleman, 2000; Cotman, Berchtold, & Christie, 2007; Van Praag, Shubert, Zhao, & Gage, 2005). Namely, it was shown that exercising increases BDNF (Brain Derived Neurotrophic Factor) levels in the hippocampus (Cotman & Berchtold, 2002), enhances learning and neurogenesis in the hippocampal regions (Van Praag et al., 2005) and optimizes spatial abilities (Creer, Romberg, Saksida, van Praag, & Bussey, 2010). The underlying protecting mechanism of physical activity and exercise on cognitive functioning in older age might be related to reduced inflammation and, therefore, not-impaired growth factor signalling in the brain and periphery (Cotman et al., 2007).

Studies in humans that have used brain-imaging techniques have revealed that physical activity and exercise have an important role in mitigating age-related structural and behavioural changes within the brain. In a study conducted by Colcombe et al. (2006) it was shown that a 6-month aerobic training resulted in significant increases of grey and white matter primarily located in prefrontal and temporal cortices. Furthermore, exercise was shown to increase hippocampal volumes, which were related to increased serum BDNF levels and improved memory as well (Erickson et al., 2011). Studies have also shown that aerobic exercise improves general cognitive functions (Weuve et al., 2004), and more specifically, aerobic exercise was shown to enhance visuospatial memory (Stroth, Hille, Spitzer, & Reinhardt, 2009) and executive control (Kramer et al., 1999). Further, some studies reported the effects and benefits of computerized cognitive training on executive functioning in older adults (Marusic et al., 2018), as well as its benefits on motor functions (Marusic et al., 2015), plasma level of the BDNF (Passaro et al., 2017) or even on vascular function (Goswami et al., 2015) after prolonged physical inactivity. Finally, the participants who exercised regularly had faster reaction times, better attention and cognitive flexibility (Masley, Roetzheim & Gualtieri, 2009; Smith et al., 2010).

Together with the above reported positive effects of physical activity on cognitive functioning in humans and animals, physical activity was shown also to have a protective effect against cognitive decline in the older age, as well as in some neurodegenerative diseases. A recent meta-analysis showed that greater amounts of physical activity earlier in life are associated with a 38% reduced risk of developing cognitive impairment later in life (Erickson et al., 2014). In a large-scale prospective cohort study that was carried out on Canadian older adult population, Laurin and colleagues (2001)

showed a positive relation between physical activity and lower risk of cognitive impairment, Alzheimer disease, and all types of dementia in the later life (Laurin, Verreault, Lindsay, MacPherson, & Rockwood, 2001). In a randomized controlled trial with 24-week physical activity intervention, older adults with memory problems (but without diagnosed dementia) showed a modest improvement in cognition (Lautenschlager et al., 2008). Positive effects of aerobic activity on medial temporal brain structures have been also registered in patients with Alzheimer's disease (Erickson et al., 2011; Yuede et al., 2009) and schizophrenia patients (Pajonk et al., 2010).

BENEFITS OF COMBINED MOTOR AND / OR COGNITIVE EXERCISE ON COGNITIVE FUNCTION IN OLDER ADULTS WITH RECOMMENDATIONS

Physical activity and high levels of cardiorespiratory / cardiovascular fitness, achieved with regular aerobic and resistance exercise / training as well as motor learning and coordinative exercise, have been shown to enhance cognitive function and decrease the risk of cognitive decline and dementia (Alzheimer's disease) in older population (Bherer, Erickson & Liu-Ambrose, 2013; Erickson, Gildengers & Butters, 2013; Erickson et al., 2014). New evidences emerge showing that the effects are even greater when physical activity and exercise are combined with (additional) cognitive tasks. This combination could be achieved so that both activities are performed separately, one after another (here we introduce the expression "*motor and cognitive exercise / training*") or simultaneously (for this we will use the expression "*motor-cognitive exercise / training*"). However, when there will be no emphasis on one of the above mentioned options, the term "*motor / cognitive exercise/training*" will be used.

Through the process of neurogenesis, many of new neuron cells are produced every day in the adult brain in the hippocampal formation, a brain structure necessary for many types of new learning, and one that is highly responsive to the effects of mental and physical training. These new neurons in the hippocampus are extremely responsive to the external environment, since physical activity and exercise have been shown to increase the number of cells that are produced, even after just one day of exercise (Curlik & Shors, 2011). Physical activity and exercise take advantage of neuroplasticity also in later life, which promotes neural, regional, and, possibly, total brain growth. The term neuroplasticity is usually used in reference to positive or adaptive (rather than maladaptive) changes to brain architecture that is above and beyond its current functioning limits (Erickson et al., 2014). As already described, the most well characterized physical activities for slowing the rate of cognitive decline and preventing dementia are the aerobic as well as resistance exercise / training, motor learning and coordinative exercise (Bherer, Erickson & Liu-Ambrose, 2013; Erickson et al., 2014). However, besides physical activity and exercise, Fratiglioni, Paillard-Borg and Winblad (2004) report that also a socially integrated network and cognitive leisure activities can play a significant role.

On the other hand, Curlik and Shors (2013) emphasize that physical training by itself is not enough to rescue new neurons from death, but learning must occur during the training process. Even more, learning has to be difficult to master in order to rescue these cells. This could be, for example, learning to associate two stimuli that overlap, but are separated by long temporal window or learning to associate two stimuli that do not occur together in time with sufficiently long temporal gap between them or learning to find the platform using only spatial cues outside the maze (Curlik & Shors, 2013). Since individual animals and humans tend to learn at different rate, it is also important how many trials are necessary to learn. Thus, it has been repeatedly shown that there are strong positive correlations between the number of trials necessary to learn the task or skill and the number of surviving cells in the animals' dentate gyrus (Curlik & Shors, 2013) – a part of the hippocampus thought to contribute to the formation of new episodic memories (Amaral, Scharfman, & Lavenex, 2007; Saab et al., 2009) – the spontaneous exploration of novel environments (Saab et al., 2009) and other functions (Scharfman, 2007), being one of a selected few brain structures currently known to have high rates of neurogenesis in adult rats (Cameron & McKay, 2001). This means that animals that need more trials of training in order to learn the skill tend to retain more cells than those that learn it with less effort. On the whole, these results show that learning has the greatest impact on neurogenesis when training task itself is challenging, and when many trials and / or days of training are required to master the skill (Curlik & Shors, 2011; Curlik & Shors, 2013). Therefore, the authors suggest that a combination of mental and physical training may result in greater cognitive gains and can have additive effects on the structure of the adult brain than either form alone, which may help to keep the brain fit for future learning. If we go a little further, greater cognitive gains could be achieved by using training regimens that combine physical and mental skill training, which in practice means motor learning. For example, learning to perform a new dance routine or when engaged in any new sports activities. These activities influence many learning processes, including working memory and require some significant degree of cognitive effort, suggesting that the mental effort intrinsic to many athletic and sporting endeavours can produce long-lasting effects in the structure of the adult brain (Curlik & Shors, 2013).

In the last 10–15 years, numerous studies (randomized exercise interventions, cross-sectional, prospective longitudinal and epidemiological studies) have been conducted to evaluate how physical activity and exercise (in the form of aerobic or resistance training, motor learning and coordinative exercise) in the adulthood and in the old age influences cognitive functions and brain structures in older adult population. However, only recently more emphasis has been given to motor / cognitive exercise strategies to maximize the effects on neural adaptations (neurogenesis) and cognitive function, in order to alleviate or prevent dementia and other neurodegenerative processes in the third age. All of them definitely require both mental and physical effort and are, thus, potentially useful to preserve or improve cognitive function in mid- and especially in late adulthood. Such strategies could include:

1. any kind of physical exercise / training followed by computerized and other forms of cognitive training,
2. simultaneously performed motor and cognitive exercise / training,
3. dancing and interactive video dancing or even
4. the ancient techniques such as Tai Ji Quan (Tai-Chi).

EFFECTS OF PHYSICAL EXERCISE / TRAINING FOLLOWED BY COMPUTERIZED AND OTHER FORMS OF COGNITIVE TRAINING

Shatil (2013) performed a four-condition randomized controlled trial among healthy older adults in order to evaluate if a 4-month mild aerobic and / or cognitive training enhance cognitive abilities more than either alone. One hundred twenty-two community dwelling and healthy older adults (65 – 93 year olds) were divided into four groups: the first group was engaged in cognitive training, the second in mild aerobic training, the third in the combination of both, and the fourth, as a control, in book-reading and discussion activities. The cognitive training intervention was performed in 48 forty-minute sessions three times per week for 16 consecutive weeks using a previously validated CogniFit® program. The mild aerobic training intervention consisted of 10 minutes of aerobic warm-up, 15 minutes of cardiovascular workout seated and standing, 5 minutes of aerobic cool-down, 10 minutes of strength training and 5 minutes of flexibility training, followed by brief relaxation; a total of 45 minutes, three times per week for 16 consecutive weeks. The combined intervention consisted of both the above mentioned interventions, receiving twice as many training sessions as the previous two groups. The control group needed to read the book “Active Living Everyday: Twenty Weeks to Lifelong Vitality” at home and held one 60-minute weekly meeting for discussion about it. The results indicate that, compared to older adults who did not engage in cognitive training (the mild aerobic and control groups), those who did (separate or combined training group) showed significant improvement in cognitive performance, especially in hand-eye coordination, global visual memory (working memory and long-term memory), speed of information processing, visual scanning, and naming words. These results and results of a similar study performed by Oswald, Gunzelmann, Ruprecht and Hagen (2006) suggest that it is the cognitive training (not mild aerobic training (Shatil, 2013) or physical training (Oswald et al., 2006)) which is driving the improvement in the combined condition (performed on separate sessions) and somehow contradict a research consensus that aerobic activity is a main mechanism in the enhancement of cognitive ability (Shatil, 2013). However, it is possible that the intensity and duration (four months only) of the interventions in the Shatil’s (2013) study were insufficiently high and long to induce cognitive gains or too broad-based (not sufficiently specific and intense) in the Oswald et al.’s (2006) study. On the other hand, positive effects of the combined interventions on cognitive function, independence of living, and some measures of health and emotional status (especially depression) could be observed up to five years after the intervention (Oswald et al., 2006). Future studies should aim to

investigate also the combination of different non-physical ways of training, such as action observation and motor imagery with physical exercise (Eaves, Riach, Holmes, & Wright, 2016).

EFFECTS OF SIMULTANEOUSLY PERFORMED MOTOR AND COGNITIVE EXERCISE / TRAINING

Further, if the effects of a simultaneously performed, motor-cognitive training intervention is compared to a single cognitive training intervention or to passive controls the motor-cognitive intervention results in larger cognitive and motor-cognitive (dual-task) improvements. In fact, Theill, Schumacher, Adelsberger, Martin and Jäncke (2013) looked at the effects of 10 weeks of simultaneously performed cognitive and physical training in 63 healthy older adults (65 – 84 year olds), who were divided in three groups. The first group simultaneously performed a verbal working memory and a cardiovascular training, while the second group performed only verbal working memory training, both for 20 training sessions two times weekly. The third group attended no training at all and served as a control. The cognitive training session contained 15 minutes of computer-based n-back training (continuous responses to a series of letters appearing all for three seconds, always comparing the subsequent letters with the letter in a given sequence n-times before) and 15 minutes of serial position training (learning a sequence of words in the correct order, presented for three seconds and followed by a distraction phase) – see Theill et al. (2013) for more details. On the other hand, the motor-cognitive training session consisted of 40-minute treadmill walking (including warm-up at a self-selected speed) at the intensity (walking speed) between 60 % and 80 % of the individual's age related maximum heart rate value ($HR_{\max} = 220 - \text{age}$), while simultaneously performing the same cognitive training as described earlier. The results indicate similar training progress and larger improvements in the executive control task for both experimental groups compared to the passive control group. However, the simultaneous, motor-cognitive training group showed larger improvements in the paired-associates task compared to the single cognitive training group and was able to reduce the step-to-step variability during the motor-cognitive dual-task condition compared to the single cognitive training group and passive controls. Thus, the authors (Theill et al., 2013) conclude that the simultaneous training of cognitive and physical abilities presents a promising concept to improve cognitive and motor-cognitive dual-task performance, offering greater potential on daily life functioning, which usually involves the recruitment of multiple abilities and resources rather than a single one.

EFFECTS OF DANCING, INTERACTIVE VIDEO DANCING AND ANCIENT BODY-MIND MEDITATIVE TECHNIQUES

Based on this premise it can be realized that even dancing and the ancient body-mind meditative exercise, such as Tai Ji Quan (Tai-Chi) is a form of motor-cognitive exercise, which requires substantial simultaneous mental and physical effort in order to be (adequately) performed. Their positive effects on physical and especially cognitive functions in older adults have recently been confirmed by several studies (Olsson, 2012). For example, Jovancevic, Rosano, Perera, Erickson and Studenski (2012) (a study protocol report) examined the effects of a 6-month interactive video dancing game intervention (using a commercially available Dance Dance Revolution system) in comparison to brisk walking (at least twice a week for 30 minutes, with a target of 150 minutes per week) and passive controls on physical and mental health, balance, attention and visual spatial skills in 168 overweight or obese, sedentary post-menopausal women (50 – 65 year olds). Similarly, Pichierri, Murer and de Bruin (2012) examined the effects of 12 weeks of additional dance video gaming to progressive strength and balance exercise on gait performance under single- and dual-task conditions (at normal and fast speed), foot placement accuracy (FPA), and falls efficacy (fear of falling questionnaire and gaze behaviour during FPA) in 31 community dwelling older adults (86.2 ± 4.6 years). Pilot findings of Jovancevic et al. (2012) suggest that interactive video dance is associated with increased fronto-parietal attention network activation and a trend towards improved reaction times, while the results of Pichierri et al. (2012) support previous findings that strength and balance exercise may lead to better walking performance in older untrained subjects. In addition, integrating a cognitive training (video dance gaming) to strength and balance exercise results in further improvements in walking performance under dual-task conditions (higher gait velocity and shorter single support time during fast dual-task walking), most likely due to functional or even structural changes in the brain (Pichierri et al., 2012). Furthermore, both interventions in the Pichierri's study reduced the concerns about falling and only the dance group improved foot placement accuracy (in the medio-lateral direction) without significant differences between the two groups after 12 weeks.

Why is this so? Interactive video dance games are a form of action video games that also require physical activity besides constant monitoring of the periphery for frequent unpredictable events that require quick and accurate responses, thus, influencing positively physical and cognitive skills, abilities and functions such as hand-eye coordination, processing in the periphery, mental rotation, divided attention and reaction times (Jovancevic et al., 2012). In fact, monitoring of the periphery places heavy demands on visual-attentional systems, as players need to keep track of many moving objects while ignoring distracters. These games also require precise visual-motor control in order to aim steps in space and time according to the sequence of moving targets (Jovancevic et al., 2012).

What about usual dancing exercise / training? Kattenstroth, Kalisch, Holt, Tegenhoff and Dinse, (2013) performed a study where 35 healthy older adults (60 – 94

year olds) were engaged in a 6-month dance intervention group one hour per week (Agilando™ dance program – it can be performed without a partner) or in a control group. Cognition, fluid intelligence, attention, reaction time, motor, tactile and postural performance, as well as subjective well-being and cardio-respiratory performance were assessed. Similarly, Hamacher, Hamacher, Rehfeld, Hökelmann and Schega (2015) examined the effects of a 6-month dancing program on motor-cognitive dual-task performance, where cognitive performance, stride-to-stride variability of minimum foot clearance, stride time and stride length while walking were measured in 35 older adults (years), who were assigned to a dancing group or a health-related exercise group. The results of Kattenstroth et al. (2013) indicate no changes or further degradation of performance after six months in the control group. On the other hand, beneficial effects were found in the dance group for dance related parameters such as posture and reaction times, cognitive, tactile and motor performance, and subjective well-being, without alterations in cardio-respiratory performance (Kattenstroth et al., 2013). Furthermore, dancing also lowers gait variability and improves cognitive performance in dual-task conditions in a greater extent than conventional health-related exercise (Hamacher et al., 2015). Thus, it could be concluded that the lack of changes of cardio-respiratory function found by Kattenstroth et al. (2013) indicate that even moderate levels of physical activity in combination with rich sensorimotor, cognitive, social, and emotional challenges can act to ameliorate a wide spectrum of age-related decline. This shows that dancing could be a powerful tool to improve motor / cognitive (dual-task) performance and it can play an important role in the maintenance of perceptual and cognitive abilities, contributing also to a reduced risk of falls in older adult population. In fact, learning new dance steps requires three-dimensional and geometric thinking, which has been associated with improved learning capabilities (Kattenstroth et al., 2013), thus, stimulating neurogenesis and preservation of new neurons as noted by Curlik and Shors (2013).

Similarly, even the ancient body-mind meditative techniques like Tai Ji Quan (Tai-Chi) represent an efficient exercise mode to preserve or improve motor / cognitive functions and performance. Recent studies demonstrate that it improves cognitive and physical function (Bherer, Erickson & Liu-Ambrose, 2013; Sun et al., 2015), coordination (Qiu & Zhu, 2003), visual span (Bherer, Erickson & Liu-Ambrose, 2013) and through improved balance (Qiu & Zhu, 2003) also the efficiency of postural control (Zhou et al., 2015). It relieves stress, reduces pain and muscle stiffness (Qiu & Zhu, 2003) and it is effective in reducing blood pressure and body mass index, maintaining normal renal function, and improving physical health of health-related quality of life (Sun & Buys, 2015). Furthermore, long-term Tai Ji Quan (Tai-Chi) exercising can also improve vagal modulations, it tends to reduce sympathetic modulations (Guo, 2015) and has shown to be the cost most effective strategy (compared to resistance training or stretching) for optimizing fall prevention in Parkinson disease patients (Li & Harmer, 2015). All of this is the scientific confirmation why our ancestors' knowledge should not be forgotten and why we should stand on their shoulders to further improve our knowledge, ourselves as human beings and to direct our actions into helping each other

as well as generations that still have to come to live a better, healthier and, thus, more contended and successful life.

CONCLUSION

Physical activity in the form of aerobic and resistance exercise leading to a high level of cardio-respiratory fitness represents a strong non-pharmacological preventive tool in the third age (Bherer, Erickson & Liu-Ambrose, 2013; Hökelmann et al., 2015). The effects are even greater if any type in this paper mentioned motor-cognitive exercise / training are performed on regular basis. It could be performed either as a simultaneous combination of a motor task (movements) with an additional cognitive task (Geržević & Dobnik, 2014; Geržević, Dobnik, & Pišot, 2014; Theill et al., 2013), as dancing or video dancing (Hamacher et al., 2015; Hökelmann et al., 2015; Jovancevic et al., 2012; Kattenstroth et al., 2013; Pichierri et al., 2012) or as a body-mind meditative exercise like Tai Ji Quan (Bherer, Erickson & Liu-Ambrose, 2013; Guo, 2015; Li & Harmer, 2015; Qiu & Zhu, 2003; Sun & Buys, 2015; Sun et al., 2015; Zhou et al., 2015).

Despite an increasing number of studies indicate a strong connection between physical activity and brain health and plasticity in late adulthood, many questions remain still open for future research. Although positive effects were found with moderate intensity exercise for several months, Bherer, Erickson and Liu-Ambrose (2013), Erickson, Gildengers & Butters (2013) and Erickson et al. (2014) noted, that the exact dose-response relationship between physical activity and mood, cognitive or brain health in older adults remains unknown. This means there is a very poor understanding of the types (aerobic exercise alone like walking, tennis, swimming or cycling; anaerobic alone like resistance exercise; combined motor and cognitive exercise, such as (simultaneous) motor-cognitive exercise, dancing or Tai Ji Quan etc.; competitive or non-competitive sports), intensity (low, moderate, high) and duration of exercise that might be most useful to promote a healthier brain. There is also a very poor understanding of what age is optimal to start exercising, as well as a poor understanding of the retention of the effects, since individuals stop exercising for a variety of different reasons including injuries, illnesses, and personal issues (e.g., mourning). It is still unknown whether the increased grey matter volume or improved white matter integrity persists after the completion of the exercise intervention or after some period of inactivity (follow-up assessments of the effects). And finally, the effects still need to be fully understood in cognitively impaired populations including persons with Alzheimer's disease, depression, and Parkinson's disease (de Dreu, Kwakkel, & van Wegen, 2015).

In the end, it could be concluded that physical activity and exercise hold great potential as inexpensive and effective methods of elevating cognitive function, improving brain health, and restoring brain function after atrophy or disease (Erickson et al., 2014).

REFERENCES

- Amaral, D., Scharfman, H. & Lavenex, P. (2007).** The dentate gyrus: fundamental neuro-anatomical organization (dentate gyrus for dummies). *Progress in Brain Research*, 163, 3–22. doi: 10.1016/S0079-6123(07)63001-5. [VIEW ITEM](#)
- Bherer, L., Erickson, K. I. & Liu-Ambrose, T. (2013).** A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. *Journal of Aging Research*, Article ID 657508. doi: 10.1155/2013/657508. [VIEW ITEM](#)
- Bishop, N. A., Lu, T., & Yankner, B. A. (2010).** Neural mechanisms of ageing and cognitive decline. *Nature*, 464(7288), 529–535. doi: 10.1038/nature08983. [VIEW ITEM](#)
- Cameron, H. A. & McKay, R. D. (2001).** Adult neurogenesis produces a large pool of new granule cells in the dentate gyrus. *The Journal of Comparative Neurology*, 435(4), 406–417. doi: 10.1002/cne.1040. [VIEW ITEM](#)
- Carro, E., Nuñez, A., Busiguina, S., & Torres-Aleman, I. (2000).** Circulating insulin-like growth factor I mediates effects of exercise on the brain. *The Journal of Neuroscience*, 20(8), 2926–2933. [VIEW ITEM](#)
- Chodzko-Zajko, W. J., Proctor D. N., Fiatarone Singh, M. A., Minson, C. T., Nigg, C. R., Salem, G. J., et al. (2009).** Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise*, 41(7), 1510–1530. doi: 10.1249/MSS.0b013e3181a0c95c [VIEW ITEM](#)
- Colcombe, S. J., Erickson, K. I., Scalf, P. E., Kim, J. S., Prakash, R., McAuley, E., et al. (2006).** Aerobic exercise training increases brain volume in aging humans. *The Journal of Gerontology Series A: Biological Sciences & Medicine Sciences*, 61(11), 1166–1170. doi: 10.1093/gerona/61.11.1166 [VIEW ITEM](#)
- Cotman, C. W., & Berchtold, N. C. (2002).** Exercise: a behavioral intervention to enhance brain health and plasticity. *Trends in Neuroscience*, 25(6), 295–301. doi: 10.1016/S0166-2236(02)02143-4 [VIEW ITEM](#)
- Cotman, C. W., Berchtold, N. C., & Christie, L. A. (2007).** Exercise builds brain health: key roles of growth factor cascades and inflammation. *Trends in Neurosciences*, 30(9), 464–472. doi: 10.1016/j.tins.2007.06.011 [VIEW ITEM](#)
- Creer, D. J., Romberg, C., Saksida, L. M., van Praag, H., & Bussey, T. J. (2010).** Running enhances spatial pattern separation in mice. *Proceedings of the National Academy of Sciences of the United States of America*, 107(5), 2367–2372. doi: 10.1073/pnas.0911725107 [VIEW ITEM](#)
- Curlik 2nd, D. M., & Shors, T. J. (2011).** Learning increases the survival of newborn neurons provided that learning is difficult to achieve and successful. *Journal of Cognitive Neuroscience* 23(9), 2159–2170. doi: 10.1162/jocn.2010.21597 [VIEW ITEM](#)
- Curlik 2nd, D. M. & Shors, T. J. (2013).** Training your brain: Do mental and physical (MAP) training enhance cognition through the process of neurogenesis in the hippocampus? *Neuropharmacology*, 64, 506–514. doi: 10.1016/j.neuropharm.2012.07.027 [VIEW ITEM](#)
- Dinse, H. R. (2006).** Cortical reorganization in the aging brain. *Progress in Brain Research*, 157, 57–80, 386–387. doi: 10.1016/S0079-6123(06)57005-0 [VIEW ITEM](#)
- de Dreu, M. J., Kwakkel, G., & van Wegen, E. E. (2015).** Partnered dancing to improve mobility for people with Parkinson's disease. *Frontiers in neuroscience*, 9, 444. doi: 10.3389/fnins.2015.00444 [VIEW ITEM](#)

- Eaves, D. L., Riach, M., Holmes, P. S., & Wright, D. J. (2016). Motor imagery during action observation: a brief review of evidence, theory and future research opportunities. *Frontiers in neuroscience*, 10, 514. doi: 10.3389/fnins.2016.00514 [VIEW ITEM](#)
- Erickson, K. I., Gildengers, A. G., & Butters, M. A. (2013). Physical activity and brain plasticity in late adulthood. *Dialogues in Clinical Neurosciences*, 15(1), 99–108. [VIEW ITEM](#)
- Erickson, K. I., Oberlin, L., Gujral, S., Leckie, R. L., Weinstein, M. W., Hodzic, J. C., et al. (2014). Exercise as a way of capitalizing on neuroplasticity in late adulthood. *Topics in Geriatric Rehabilitation*, 30(1), 8–14. doi: 10.1097/TGR.0000000000000008 [VIEW ITEM](#)
- Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., et al. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences of the United States of America*, 108(7), 3017–3022. doi: 10.1073/pnas.1015950108 [VIEW ITEM](#)
- Fratiglioni, L., Paillard-Borg, S., & Winblad, B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *The Lancet Neurology*, 3(6), 343–353. doi: 10.1016/S1474-4422(04)00767-7 [VIEW ITEM](#)
- Geržević, M., & Dobnik, M. (2014). Gibalno-kognitivna vadba: praktična delavnica [Motor-cognitive exercise: practical workshop]. *eSinapsa* 2014(7). Retrived on August 11th 2015, from: <http://www.sinapsa.org/eSinapsa/stevilke/2014-7/107/Gibalno-kognitiv-na%20vadba:%20prakti%C4%8Dna%20delavnica>.
- Geržević, M., Dobnik, M., & Pišot, R. (2014). Telesna aktivnost in prehrana za kakovostno staranje: Priročnik o telesni aktivnosti in vadbi v tretjem življenjskem obdobju [Physical activity and nutrition for quality aging: Handbook on physical activity and exercise in the third age]. Koper: Univerzitetna založba Annales, 2014. [VIEW ITEM](#)
- Gradari, S., Pallé, A., McGreevy, K. R., Fontán-Lozano, Á., & Trejo, J. L. (2016). Can exercise make you smarter, happier, and have more neurons? A hormetic perspective. *Frontiers in neuroscience*, 10, 93. doi: 10.3389/fnins.2016.00093 [VIEW ITEM](#)
- Goswami, N., Kavcic, V., Marusic, U., Simunic, B., Rössler, A., Hinghofer-Szalkay, H. et al. (2015). Effect of computerized cognitive training with virtual spatial navigation task during bed rest immobilization and recovery on vascular function: a pilot study. *Clinical Interventions in Aging*, 10, 453–459. doi: 10.2147/CIA.S76028 [VIEW ITEM](#)
- Gregory, S. M., Parker, B., & Thompson, P. D. (2012). Physical activity, cognitive function, and brain health: what is the role of exercise training in the prevention of dementia? *Brain Sciences*, 2(4), 684–708. doi:10.3390/brainsci2040684 [VIEW ITEM](#)
- Guo, F. (2015). Effects of long-term Tai Ji Quan exercise on automatic nervous modulation in the elderly. *Zhongguo Ying Yong Sheng Li Xue Za Zhi*, 31(2), 158–163.
- Hamacher, D., Hamacher, D., Rehfeld, K., Hökelmann, A., & Schega, L. (2015). The effect of a six months dancing program on motor-cognitive dual task performance in older adults. *Journal of Aging and Physical Activity*, 23(4), 647–652. doi: 10.1123/japa.2014-0067 [VIEW ITEM](#)
- Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: exercise effects on brain and cognition. *Nature Reviews Neuroscience*, 9(1), 58–65. doi: 10.1038/nrn2298 [VIEW ITEM](#)
- Hökelmann, A., Rehfeld, K., Dordevič, M., Gujar, T. A., Henrichs, K., & Partie, M. (2015). Motor and cognitive intervention after (hip) surgery – novel approaches in rehabilitation strategies. In U. Marušič, B. Šimunič, R. Pišot (Eds.), *Hip fracture in the*

- elderly – reasons, consequences and rehabilitation (pp. 77–112). Koper: Univerzitetna založba Annales.
- Jovancevic, J., Rosano, C., Perera, S., Erickson, K. I. & Studenski, S. (2012).** A protocol for a randomized clinical trial of interactive video dance: potential for effects on cognitive function. *BMC Geriatrics*, 12(23), 1–9. doi: 10.1186/1471-2318-12-23 [VIEW ITEM](#)
- Kattenstroth, J. C., Kalisch, T., Holt, S., Tegenthoff, M., & Dinse, H. R. (2013).** Six months of dance intervention enhances postural, sensorimotor, and cognitive performance in elderly without affecting cardio-respiratory functions. *Frontiers in Aging Neuroscience*, 5(5), 1–16. doi: 10.3389/fnagi.2013.00005 [VIEW ITEM](#)
- Kempermann, G., Fabel, K., Ehninger, D., Babu, H., Leal-Galicia, P., Garthe, A., & Wolf, S. A. (2010).** Why and how physical activity promotes experience-induced brain plasticity. *Frontiers in neuroscience*, 4, 189. doi: 10.3389/fnins.2010.00189 [VIEW ITEM](#)
- Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., McAuley, E., Harrison, C. R., et al. (1999).** Ageing, fitness and neurocognitive function. *Nature*, 400(6743), 418–419. doi: 10.1038/22682 [VIEW ITEM](#)
- Kramer, A. F., & Erickson, K. I. (2007).** Capitalizing on cortical plasticity: influence of physical activity on cognition and brain function. *Trends in Cognitive Sciences*, 11(8), 342–348. doi: 10.1016/j.tics.2007.06.009 [VIEW ITEM](#)
- Laurin, D., Verreault, R., Lindsay, J., MacPherson, K., & Rockwood, K. (2001).** Physical activity and risk of cognitive impairment and dementia in elderly persons. *Archives of Neurology*, 58(3), 498–504. doi: 10.1001/archneur.58.3.498 [VIEW ITEM](#)
- Lautenschlager, N. T., Cox, K. L., Flicker, L., Foste, J. K., van Bockxmeer, F. M., Xiao, J., et al. (2008).** Effect of physical activity on cognitive function in older adults at risk for alzheimer disease: A randomized trial. *JAMA*, 300(9), 1027–1037. doi: 10.1001/jama.300.9.1027 [VIEW ITEM](#)
- Li, F., & Harmer, P. (2015).** Economic evaluation of a Tai Ji Quan intervention to reduce falls in people with parkinson disease, Oregon, 2008–2011. *Preventing Chronic Disease*, 12: E120. doi: 10.5888/pcd12.140413 [VIEW ITEM](#)
- Marusic, U., Giordani, B., Moffat, S. D., Petrič, M., Dolenc, P., Pišot, R., et al. (2018).** Computerized cognitive training during physical inactivity improves executive functioning in older adults. *Aging, Neuropsychology, and Cognition*, 25(1), 49–69. doi: 10.1080/13825585.2016.1263724 [VIEW ITEM](#)
- Marusic, U., Kavcic, V., Giordani, B., Gerževič, M., Meeusen, R., & Pišot, R. (2015).** Computerized spatial navigation training during 14 days of bed rest in healthy older adult men: Effect on gait performance. *Psychology and aging*, 30(2), 334–340. doi: 10.1037/pag0000021 [VIEW ITEM](#)
- Masley, S., Roetzheim, R., & Gualtieri, T. (2009).** Aerobic exercise enhances cognitive flexibility. *Journal of Clinical Psychology in Medical Settings*, 16(2), 186–193. doi: 10.1007/s10880-009-9159-6 [VIEW ITEM](#)
- Masud, T. & Morris, O. R. (2001).** Epidemiology of falls. *Age and Ageing*, 30(Suppl4), 3–7.
- Netz, Y., Wu, M.-J., Becker, B. J., & Tenenbaum, G. (2005).** Physical activity and psychological well-being in advanced age: a meta-analysis of intervention studies. *Psychology and Aging*, 20(2), 272–284. doi: 10.1037/0882-7974.20.2.272 [VIEW ITEM](#)
- Olsson, C. J. (2012).** Dancing combines the essence for successful aging. *Frontiers in neuroscience*, 6, 155. doi: 10.3389/fnins.2012.00155 [VIEW ITEM](#)

- Oswald, W. D., Gunzelmann, T., Ruprecht, R., & Hagen, B. (2006).** Differential effects of single versus combined cognitive and physical training with older adults: the SimA study in a 5-year perspective. *European Journal of Ageing*, 3, 179–192. doi: 10.1007/s10433-006-0035-z [VIEW ITEM](#)
- Pajonk, F. G., Wobrock, T., Gruber, O., Scherk, H., Berner, D., Kaizl, I., et al. (2010).** Hippocampal plasticity in response to exercise in schizophrenia. *Archives of General Psychiatry*, 67(2), 133–143. doi: 10.1001/archgenpsychiatry.2009.193 [VIEW ITEM](#)
- Passaro, A., Soavi, C., Marusic, U., Rejc, E., Sanz, J. M., Morieri, M. L., et al. (2017).** Computerized cognitive training and brain derived neurotrophic factor during bed rest: mechanisms to protect individual during acute stress. *Aging (Albany NY)*, 9(2), 393–407. doi: 10.18632/aging.101166 [VIEW ITEM](#)
- Penedo, F. J., & Dahn, J. R. (2005).** Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, 18(2), 189–193. [VIEW ITEM](#)
- Pichierri, G., Murer, K., & de Bruin, E. D. (2012).** A cognitive-motor intervention using a dance video game to enhance foot placement accuracy and gait under dual task conditions in older adults: a randomized controlled trial. *BMC Geriatrics*, 12(74), 1–14. doi: 10.1186/1471-2318-12-74 [VIEW ITEM](#)
- Pišot, R., Marusic, U., Biolo, G., Mazzucco, S., Lazzer, S., Grassi, B., et al. (2016).** Greater loss in muscle mass and function but smaller metabolic alterations in older compared with younger men following 2 wk of bed rest and recovery. *Journal of Applied Physiology*, 120(8), 922–929. doi: 10.1152/jappphysiol.00858.2015 [VIEW ITEM](#)
- Qiu, M. P., & Zhu, W. (2003).** *Tai Chi illustrated*. Champaign: Human Kinetics.
- Rejeski, W. J., & Mihalko, S. L. (2001).** Physical activity and quality of life in older adults. *The Journals of Gerontology Series A: Biological Sciences & Medical Sciences*, 56(suppl 2), 23–35. doi: 10.1093/gerona/56.suppl_2.23 [VIEW ITEM](#)
- Richardson, J. K. & Ashton-Miller, J. A. (1996).** Peripheral neuropathy: an often-overlooked cause of falls in the elderly. *Postgraduate Medicine*, 99(6), 161–172. doi: 10.1080/00325481.1996.11946142 [VIEW ITEM](#)
- Rubenstein, L. Z. (2006).** Falls in older people: epidemiology, risk factors and strategies for prevention. *Age and Ageing*, 35,(Suppl2), ii37–ii41. doi: 10.1093/ageing/afl084 [VIEW ITEM](#)
- Saab, B. J., Georgiou, J., Nath, A., Lee, F. J., Wang, M., Michalon, A., et al. (2009).** NCS-1 in the dentate gyrus promotes exploration, synaptic plasticity, and rapid acquisition of spatial memory. *Neuron*, 63(5), 643–656. doi: 10.1016/j.neuron.2009.08.014 [VIEW ITEM](#)
- Sattin, R. W. (1992).** Falls among older persons: A public health perspective. *Annual Review of Public Health*, 13, 489–508. doi: 10.1146/annurev.pu.13.050192.002421 [VIEW ITEM](#)
- Scharfman, H. (2007).** *The Dentate Gyrus: A comprehensive guide to structure, function, and clinical implications*. Amsterdam: Elsevier.
- Shatil, E. (2013).** Does combined cognitive training and physical activity training enhance cognitive abilities more than either alone? A four-condition randomized controlled trial among older adults. *Frontiers in Aging Neuroscience*, 5(8), 1–12. doi: 10.3389/fnagi.2013.00008. [VIEW ITEM](#)
- Smith, P. J., Blumenthal, J. A., Hoffman, B. M., Cooper, H., Strauman, T. A., Welsh-Bohmer, K., et al. (2010).** Aerobic exercise and neurocognitive performance: a meta-

- analytic review of randomized controlled trials. *Psychosomatic Medicine*, 72(3), 239–252. doi: 10.1097/PSY.0b013e3181d14633. [VIEW ITEM](#)
- Stroth, S., Hille, K., Spitzer, M., & Reinhardt, R. (2009).** Aerobic endurance exercise benefits memory and affect in young adults. *Neuropsychological Rehabilitation*, 19(2), 223–243. doi: 10.1080/09602010802091183. [VIEW ITEM](#)
- Sun, J., & Buys, N. (2015).** Community-based mind-body meditative Tai Chi program and its effects on improvement of blood pressure, weight, renal function, serum lipoprotein, and quality of life in chinese adults with hypertension. *American Journal of Cardiology*, 116(7), 1076–1081. doi: 10.1016/j.amjcard.2015.07.012. [VIEW ITEM](#)
- Sun, J., Kanagawa, K., Sasaki, J., Ooki, S., Xu, H., & Wang, L. (2015).** Tai chi improves cognitive and physical function in the elderly: a randomized controlled trial. *Journal of Physical Therapy Science*, 27(5), 1467–1471. Doi: 10.1589/jpts.27.1467 [VIEW ITEM](#)
- Theill, N., Schumacher, V., Adelsberger, R., Martin, M., & Jäncke, L. (2013).** Effects of simultaneously performed cognitive and physical training in older adults. *BMC Neuroscience*, 14(103), 1–14. doi: 10.1186/1471-2202-14-103 [VIEW ITEM](#)
- Van Praag, H., Shubert, T., Zhao, C., & Gage, F. H. (2005).** Exercise enhances learning and hippocampal neurogenesis in aged mice. *The Journal of Neuroscience*, 25(38), 8680–8685. doi: 10.1523/JNEUROSCI.1731-05.2005 [VIEW ITEM](#)
- Weuve, J., Kang, J. H., Manson, J. E., Breteler, M. M., Ware, J. H., & Grodstein, F. (2004).** Physical activity, including walking, and cognitive function in older women. *JAMA*, 292(12), 1454–1461. doi: 10.1001/jama.292.12.1454 [VIEW ITEM](#)
- Yuede, C. M., Zimmerman, S. D., Dong, H., Kling, M. J., Bero, A. W., Holtzman, D. M., et al. (2009).** Effects of voluntary and forced exercise on plaque deposition, hippocampal volume, and behavior in the Tg2576 mouse model of Alzheimer's disease. *Neurobiology of Disease*, 35(3), 426–432. doi: 10.1016/j.nbd.2009.06.002 [VIEW ITEM](#)
- Zhou, J., Chang, S., Cong, Y., Qin, M., Sun, W., Lian, J., et al. (2015).** Effects of 24 weeks of Tai Chi exercise on postural control among elderly women. *Research in Sports Medicine*, 23(3): 302–314. doi: 10.1080/15438627.2015.1040918 [VIEW ITEM](#)

REPORT FROM THE 2nd ROUND TABLE »A KINESIOLOGIST IN THE LABOUR MARKET«

Slovenian Association of Kinesiology,
Faculty of Sport, Ljubljana, 20th April 2017

The Slovenian Association of Kinesiology decided to organize another round table, after the first one which was held in Koper on 8th November 2016. About 50 students took part in the event at the Faculty of Sport on 20th of April 2017. While at the first round table the role and importance of the study of kinesiology in the society was presented and also the current situation and the possibilities for placement of the profession into the labour market were discussed, determining what obstacles we encounter, the purpose of the second round table was somewhat different.

The main aim of the second round table was the presentation of young successful kinesiologists and the obstacles in the field of employment that they need to surpass in their careers. The invited kinesiologists briefly presented what they are doing, how their career started, which obstacles they encountered and how they have overcome them. They also gave their view of the future of kinesiology. Official guests of the round table were: Luka Hren (One of the founders of KinVital d.o.o.) who presented an example of a successful independent career in the field of kinesiology; Katja Vodopivec (employed at the private physiotherapeutic Centre Remedios in Maribor) who presented the connection between kinesiology and physiotherapy; Matej Kleva (employed at the Science and Research Centre of Koper, Institute for Kinesiology Research) who presented an example of the application of scientific knowledge into practice; Suzana Pustivšek and Aljaž Valič (employed in health centres in the project titled “The development of personnel in sport of the Ministry of Education, Science and Sport”) who presented the work of a kinesiologist in health centres. Last but not least, Anja Šešum (member of the Ilka Štuhec team) as one of the best known kinesiologists in Slovenia presented her approach and work in the Ilka Štuhec team.

At the second round table “A kinesiologist at the labour market” we were focused on the present and the future work of successful young kinesiologists. In the conclusion, once again the right direction of Slovenian Association of Kinesiology was confirmed, despite the fact that the current situation and possibilities for placing the profession of a kinesiologist into the labour market are not in ideal position. Nevertheless, the profession enables endless possibilities for working in various fields of society.

Matej Kleva

POROČILO IZ 2. OKROGLE MIZE: »KINEZIOLOG NA TRGU DELA«

Društvo kineziologov Slovenije,
Fakulteta za šport, Ljubljana, 20. april, 2017

Po izvedeni prvi okrogli mizi 8. novembra 2016 v Kopru, se je Društvo kineziologov Slovenije odločilo za izvedbo še druge okrogle mize na isto temo. Dogodka, ki je potekal na Fakulteti za šport Univerze v Ljubljani, se je udeležilo 50 študentov. Na prvi okrogli mizi je bila predstavljena vloga in pomen študija kineziologije v družbi in izpostavljeno je bilo trenutno stanje ter možnosti za umestitev poklica na trg dela ter ovire s katerimi se pri tem srečujemo. Namen tokratne okrogle mize pa je bil predstavitev mladih uspešnih kineziologov, ki so določene ovire na področju zaposlovanja že presegli. Gostje so na kratko predstavili s čim se ukvarjajo in kako se je začela njihova karierna pot, s katerimi ovirami se srečujejo in kako jih premagujejo. Ob tem so izpostavili tudi svoj pogled na prihodnost kineziologije. Povabljeni gostje na okrogli mizi so bili: Luka Hren (eden od ustanoviteljev podjetja KinVital d.o.o), ki je predstavil primer uspešne samostojne poti na področju kineziologije; Katja Vodopivec (zaposlena v zasebnem fizioterapevtskem Centru Remedios v Mariboru), ki je predstavila povezavo med kineziologijo in fizioterapijo, Matej Kleva (zaposlen na Znanstveno-raziskovalnem središču Koper, Inštitut za kineziološke raziskave), ki je predstavil primer prenosa znanstvenih dognanj v prakso; Suzana Pustivšek in Aljaž Valič (zaposlena v zdravstvenih centrih preko razpisa Razvoj kadrov v športu Ministrstva za izobraževanje, znanost in šport), ki sta predstavila delo kineziologa v zdravstvenih domovih ter Anja Šešum (članica ekipe Ilke Štuhec), kot ena izmed trenutno najbolj znanih kineziologinj v Sloveniji, ki je predstavila pristop in delo v ekipi vrhunske smučarke Ilke Štuhec.

Na drugi okrogli mizi so gostje izpostavili prakse dela uspešnih mladih kineziologov, udeleženci pa so prisluhnili njihovem pogledu na stroko in željam za prihodnost. Vnovič je bila potrjena vizija Društva kineziologov Slovenije, da kljub temu, da trenutno stanje in možnosti za umestitev poklica kineziologa na trg dela še niso takšne kot bi morale biti, stroka omogoča neskončno možnosti za delovanje na različnih področjih.

Matej Kleva

1st SCIENTIFIC CONFERENCE SPE BALKAN SKI

Kopaonik Ski Resort, Serbia, 12th–16th March 2017

The desire and willingness to cooperate in the field of winter sports has always been present in the Balkan countries. Various forms of cooperation have long been present, however, limited at individual or, mostly institutional level. There have always been cooperation initiatives that would systemically link the ski experts of the Balkan Peninsula, but somehow they have not been realised. After the Slovenian team had returned from the Interski Congress in Argentina at the end of 2015, we were able to share our impressions and experience we had gained in Argentina with our Serbian colleagues in Kopaonik and Bosnian colleagues in Jahorina in the winter of 2016. This was the starting point from which the idea to organise a Balkan Ski Congress according to the Interski model arose. The main idea was to combine science, practice and education in the field of winter sports, to enhance interest in the wider scientific and professional public as well as to enrich ski companionship and to involve other professionals who have a common interest in the field of winter sports. This led to organising the SPE (Science, Practice & Education) Balkan Ski Conference.



Good previous experience was the reason for choosing the Kopaonik Ski Resort as the venue of the first Conference, and building on excellent collaboration between all the major players in the scientific and technical fields guarantees a successful organisation of the event. All the associations that unite skiing trainers and teachers in this area immediately supported the idea of the Conference. International response was achieved with the presentation of the SPE Balkan Ski Conference at the ICSS – International Conference of Science and Ski, in December 2016 in St. Christoph, Austria and its promotion was fostered through the ECSS European College of Sport Science official site. An important added value was the excellency of the guest speakers who came from different parts of the world and, of course, the audience; ski enthusiasts, researchers, professors, trainers and ski teachers.

Over 120 participants from 14 countries of the Balkans (Bosnia and Herzegovina, Montenegro, Croatia, Macedonia, Slovenia and Serbia) and others (the USA, Great Britain, Italy, Czech Republic, Lithuania ...) registered for the Conference and we are sure that the first SPE Balkan Ski Conference fulfilled the main goals that the organisers set forward – to empower, advocate, develop and promote ski professions, as well as to consider scientific and professional bases in theory and practice.

Besides theoretical lectures and workshops, for which our international guest lecturers contributed a special added value, practical work on the slopes was very important for the full success of the Conference. Workshops that were led by experts and the members of demo teams from the participating countries opened up new insights in learning and instructing how to ski.

To guarantee the success of the conference and promote its vision, it was also important to develop a network of excellence by bringing together ski experts, i.e. ski instructors, coaches, scientists and other ski professionals from the Balkan region, and make their integration and networking possible. At the opening session, the participants were greeted and welcomed by a ski legend and one of the best skiers of all times in the Balkan region, Bojan Križaj, whilst the Bulgarian colleagues presented the Interski Pamporovo 2019 meeting. Mingling and setting up potential collaborations between ski instructors played an important role during the following days, culminating on Wednesday, March 15 with the Balkan Ski Demo Show when all the national demo teams from the participating countries and some registered ski schools from the Balkan area introduced themselves jointly as well as individually.

The 2nd SPE Balkan Ski Congress will be organized from March 11th to 15th, 2018 in Jahorina Ski Resort in Bosnia and Herzegovina, where the 1984 Winter Olympics also took place.

Rado Pišot

1. ZNANSTVENA KONFERENCA SPE BALKAN SKI

Smučarsko središče Kopaonik, Srbija, 12.–16. marec 2017

Med državami Balkana je bila od nekdanj prisotna želja in pripravljenost, da bi sodelovale na področju zimskih športov. Različne oblike sodelovanja so sicer prisotne že dalj časa, vendar so večinoma omejene na osebno ali največ institucionalno raven. Ves čas je čutiti tudi prisotnost najrazličnejših iniciativ za sistematično povezovanje smučarskih strokovnjakov, ki pa žal v praksi nikoli niso resnično zaživele. Po povratku slovenskih udeležencev iz kongresa Interski v Argentini ob koncu leta 2015, smo imeli možnost deliti tam pridobljene vtise in izkušnje, najprej s kolegi iz Srbije na Kopaoniku, kasneje pa še s kolegi iz Bosne in Hercegovine na Jahorini. Ti dve srečanju pozimi 2016 sta bili izhodiščni točki, iz katerih je izšla ideja, da bi po vzoru kongresov Interski organizirali tudi Balkanski smučarski kongres. Osnovno vodilo pri tem je bilo, da bi združili vidike znanosti, prakse in vzgoje na področju zimskih športov. Inicijatorji ideje so s tem želeli povečati zanimanje širše znanstvene in strokovne javnosti, obogatiti smučarsko druženje ter v dogajanje pritegniti širši krog strokovnjakov, ki jih družijo sku-



pni interes na področju zimskih športov. Vse to je privedlo do organizacije konference SPE (Science, Practice & Education / Znanost, stroka in vzgoja) BALKAN SKI.

Dobre pretekle izkušnje s tem prizoriščem so bile razlog, da je bilo za kraj izvedbe prve konference izbrano smučarsko središče Kopaonik. Številna predhodna izvrstna sodelovanja med vsemi glavnimi akterji tako na znanstvenih kot tudi strokovnih področjih pa so zagotavljala organizacijo na najvišjem nivoju. Vse organizacije, ki na izbranem področju kakorkoli združujejo smučarske trenerje in učitelje, so idejo o konferenci nemudoma podprle. Za mednarodni odziv so organizatorji poskrbeli s tem, da so SPE BALKAN SKI decembra 2016 predstavili na konferenci ICSS (International Conference of Science and Ski), ki je potekala v kraju St. Christoph v Avstriji, ter s promocijo preko uradne spletne strani ECSS (European College of Sport Science). Pomembno dodano vrednost h konferenci so prispevali izvrstni povabljeni predavatelji iz različnih delov sveta ter seveda pričakovani udeleženci, smučarski navdušenci, raziskovalci, profesorji, trenerji in učitelji smučanja.

Na konferenco se je prijavilo preko 120 udeležencev iz 14 držav iz Balkana (Bosna in Hercegovina, Črna Gora, Hrvaška, Makedonija, Slovenija in Srbija) ter od drugod (ZDA, Velika Britanija, Italija, Republika Češka, Litva, ...). Prepričani smo, da je prva konferenca SPE BALKAN SKI v celoti dosegla cilje, ki so si jih zastavili organizatorji, in sicer opolnomočiti, promovirati in razvijati smučarsko stroko ter tako v teoriji kot praksi zagotoviti znanstveno in strokovno osnovo.

Poleg teoretičnih predavanj in delavnic, ki so jim posebno dodano vrednost zagotovili mednarodni gostujoči predavatelji, so bile pomemben del konference tudi praktične demonstracije na zasneženih pobočjih Kopaonika. Delavnice, ki so jih vodili strokovnjaki, člani demonstracijskih ekip posameznih držav udeleženk, so ponudile nov vpogled v tehnike učenja smučanja.

Za uspeh konference in doseganje njene vizije je bila pomembna tudi vzpostavitev kvalitetne mreže, ki bi povezala strokovnjake iz različnih področij; inštruktorje smučanja, trenerje, znanstvenike in druge, ki se kakorkoli ukvarjajo s smučanjem, iz Balkanskih držav. Na otvoritveni slovesnosti je udeležence konference pozdravil Bojan Križaj, smučarska legenda in eden najboljših smučarjev vseh časov iz te regije. Kolegi iz Bolgarije pa so predstavili prihodnje srečanje Interski Pamporovo 2019. Druženje in vzpostavljanje morebitnih bodočih sodelovanj med učitelji smučanja je bilo vodilo dogajanja prihodnjih dni konference. Ta je svoj vrhunec nedvomno doživela v sredo, 15. marca, ko so se nacionalne demonstracijske skupine držav udeleženk in prijavljenih smučarskih šol predstavile v Balkan Ski Demo Show-u tako v skupnem nastopu kot tudi individualno.

Naslednja, 2. SPE Balkan Ski konferenca, bo potekala od 11. do 15. marca 2018 v smučarskem središču Jahorina v Bosni in Hercegovini, prizorišču zimskih olimpijskih iger leta 1984.

Rado Pišot

36th INTERNATIONAL CONFERENCE ON ORGANIZATIONAL SCIENCE DEVELOPMENT

Portorož, Slovenia, 22nd–24th March 2017

Faculty of Organizational Sciences, University of Maribor organized a traditional International Conference on organizational science development and this year's theme was responsible organization. From kinesiological sciences' point of view, an important section of the Conference was Management in Sport and within this section a special event titled "Dual Career of Athletes and Social Responsibility". The latter was organized by Faculty of Organizational Sciences (UM), Ministry of Education, Science and Sport and Olympic Committee of Slovenia, Association of Sports Federations. The section was divided into two parts: a presentation of views on the dual career of Slovenian athletes by key stakeholders and a round table.

The views on understanding and further development of dual career of Slovenian athletes were presented by the representatives of regulators and decision makers (Simona Kustec Lipicer, the member of the Slovenian Parliament; Boro Štrumbelj from the Ministry of Education, Science and Sport, Directorate for Sport; Edvard Kolar from the Olympic Committee of Slovenia, Secretary General; Maja Makovec Brenčič, the Minister of Education, Science and Sport of Slovenian Government); as well as businesses and companies dealing with human resources management (Rene Mlekuž, the representative of the Peak company in Slovenia and the sponsor of Olympic Committee of Slovenia, the Association of Sports Federations and Damir Battisti from Addeco Slovenia) and the representatives from education sector (Marko Ferjan from the University of Maribor).

The starting point of the round table discussion was dedicated to the preliminary results of the Erasmus + project "Regional Centre for Dual Career Politics and Advocacy" (DC4AC) which took place at the Scientific and Research Centre Koper. Namely, a survey was presented, offering an insight into the situation in this field as perceived by some present and former Slovenian athletes. In addition to the representatives of key stakeholders in the field of dual career, the Ombudsman and the representative of the Austrian organization KADA all actively participated in the discussion. The latter presented the Austrian model of dual career, which is often referred to by the international profession as an example of good practice. In recent years, athletes' dual career has become an extremely topical issue at the international level, and with events like this it is becoming an important item on the national agenda.

Blaž Lenarčič

36. MEDNARODNA KONFERENCA O RAZVOJU ORGANIZACIJSKIH ZNANOSTI

Portorož, Slovenija, 22.–24. marec 2017

Fakulteta za organizacijske vede Univerze v Mariboru je organizirala tradicionalno mednarodno Konferenco o razvoju organizacijskih znanosti, katere osrednja tema je bila odgovorna organizacija. Z vidika kinezioloških znanosti je bila pomembna sekcija Management v športu, v okviru katere se je odvil poseben dogodek z naslovom »Dvojna kariera športnikov in družbena odgovornost«, ki so ga organizirali Fakulteta za organizacijske vede, Ministrstvo za izobraževanje, znanost in šport ter Olimpijski komite Slovenije – Združenje športnih zvez. Sekcija je bila razdeljena na dva dela: predstavitev pogledov na dvojno kariero slovenskih športnikov s strani ključnih deležnikov in okroglo mizo.

Pogleda na razumevanje in nadaljnji razvoj dvojne kariere slovenskih športnikov so predstavili predstavniki zakonodajalcev in odločevalcev (Simona Kustec Lipicer, poslanka DZ, Boro Štrumbelj, direktor Direktorata za šport, Ministrstvo za izobraževanje, znanost in šport RS, Edvard Kolar, generalni sekretar Olimpijskega komiteja Slovenije – Združenja športnih zvez in Maja Makovec Brenčič, Ministrica, Ministrstvo za izobraževanje, znanost in šport RS), gospodarstva in podjetja za kadrovske management (Rene Mlekuž, predstavnik podjetja Peak v Sloveniji, sponzor Olimpijskega komiteja Slovenije – Združenja športnih zvez in Damir Battisti, Adecco Slovenija) ter izobraževalnega sektorja (Marko Ferjan, Univerza v Mariboru).

Izhodišče diskusije okrogle mize so bili preliminarni rezultati Erasmus+ projekta Regionalni center za omogočanje dvojne poklicne poti športnikov (DC4AC), ki so ga izvajali na Znanstveno-raziskovalnem središču Koper. Predstavljena je bila raziskava, s pomočjo katere smo pridobili vpogled v stanje na tem področju, kot ga dojemajo aktualni in nekdanji slovenski športniki. Poleg predstavnikov ključnih deležnikov dvojne kariere sta v diskusiji aktivno sodelovala še varuh športnikovih pravic in predstavnik avstrijske organizacije KADA. Slednji je skozi pogovor predstavil avstrijski model dvojne kariere, ki ga mednarodna stroka pogosto navaja kot primer dobre prakse.

V zadnjih letih je postala dvojna kariera športnikov izjemno aktualna tema na mednarodnem nivoju in z dogodki, kot je bil tu predstavljeni, postaja pomembna vsebina nacionalne agende.

Blaž Lenarčič

CONFERENCE REPORT: 8th INTERNATIONAL SCIENTIFIC CONFERENCE ON KINESIOLOGY - 20th ANNIVERSARY

Opatija, Croatia, 10th–14th May 2017

In the middle of May 2017, Rado Pišot, Boštjan Šimunič and Saša Pišot were attending the 8th International Scientific Conference on Kinesiology in Opatija, Croatia. Under the organisation of Faculty of Kinesiology at University of Zagreb, they successfully hosted around 380 delegates from 31 countries and provided great intellectual and social interaction for the participants. During the conference 252 papers, written by 579 authors were presented in 10 conference sessions: Adapted Physical Activity and Kinesitherapy; Biology and Medicine of Sport and Exercise; Biomechanics and Motor Control; Physical Education; Kinesiological Recreation; Kinesiology of Top-level Sport; Kinesiology and Social Sciences (Sociology, Psychology, History, Philosophy); Kinesiology in Physical Conditioning – Management of Sport and Research Methodology. Together with three satellite symposiums: Health Kinesiology, New technologies in Physical Education and Science in Dance enable participants to provide a forum for the latest research, theoretical and applicative insights, findings and experiences from the vast field of kinesiology, the science of human movement and exercise.

The Conference gave us the expected added value and impetus to further cooperation between participants and institutions, so we are looking forward for next 9th International Conference on Kinesiology in 2020.

Saša Pišot

POROČILO Z 8. MEDNARODNE ZNANSTVENE KONFERENCE O KINEZILOGIJI (20. OBLETNICA)

Opatija, Hrvaška, 10.–14. maj 2017

Sredi maja 2017 smo se Rado Pišot, Boštjan Šimunič in Saša Pišot udeležili 8. mednarodne znanstvene konference o kineziologiji v Opatiji na Hrvaškem. Kineziološka fakulteta Univerze v Zagrebu je uspešno gostila okoli 380 delegatov iz 31 držav in zagotovila prijetno intelektualno in socialno druženje udeležencev. V štirih dneh konference je bilo v desetih sekcijah predstavljeno 252 prispevkov skupno 579 avtorjev. Posamezne sekcije so bile posvečene naslednjim področjem: Prilagojena telesna dejavnost in kinezioterapija; Biologija, medicina športa in trening; Biomehanika in motorični nadzor; Športna vzgoja; Kineziološka rekreacija; Kineziologija vrhunškega športa; Kineziologija in družboslovje (sociologija, psihologija, zgodovina, filozofija); Kineziologija v fizičnem okolju – Upravljanje v športu in Raziskovalna metodologija. Skupaj s tremi satelitskimi simpoziji: Kineziologija zdravja, Nove tehnologije v športnem izobraževanju in Znanosti v plesu, ki so potekali vzporedno s konferenco, so udeležencem omogočile vpogled v najnovejše raziskave, teoretične in aplikativne vidike, ugotovitve in izkušnje iz obsežnega področja kineziologije, znanosti o gibanju človeka in treningu.

Konferenca je prinesla pričakovano dodano vrednost in spodbudo za nadaljnje sodelovanje med udeleženci in institucijami, zato se veselimo naslednje 9. mednarodne konference o kineziologiji, ki bo potekala leta 2020.

Saša Pišot

GUIDELINES FOR AUTHORS

1. Aim and scope of the journal:

Annales Kinesiologiae is an international interdisciplinary journal covering kinesiology and its related areas. It combines fields and topics directed towards the study and research of human movement, physical activity, exercise and sport in the context of human life style and influences of specific environments. The journal publishes original scientific articles, review articles, technical notes and reports.

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Journal articles

Šarabon, N., Kern, H., Loeffler, S., & Rošker, J. (2010). Selection of body sway parameters according to their sensitivity and repeatability. *Basic and Applied Myology*, 20, 5–12.

De Boer, M. D., Seynnes, O., Di Prampero, P., Pišot, R., Mekjavić, I., Biolo, G., et al. (2008). Effect of 5 weeks horizontal bed rest on human muscle thickness and architecture of weight bearing and non-weight bearing muscles. *European Journal of Applied Physiology*, 104(2), 401–407.

Book chapters

Šimunič, B., Pišot, R., Mekjavić, I. B., Kounalakis, S. N., & Eiken, O. (2008). Orthostatic intolerance after microgravity exposures. In R. Pišot, I. B. Mekjavić, & B. Šimunič (Eds.),

The effects of simulated weightlessness on the human organism (pp. 71–78). Koper: University of Primorska, Scientific and Research Centre of Koper, Publishing house Annales.

Rossi, T., & Cassidy, T. (in press). Teachers' knowledge and knowledgeable teachers in physical education. In C. Hardy, & M. Mawer (Eds.), *Learning and teaching in physical education*. London (UK): Falmer Press.

Conference proceeding contributions

Volmut, T., Dolenc, P., Šetina, T., Pišot, R., & Šimunič, B. (2008). Objectively measured physical activity in girls and boys before and after long summer vacations. In V. Štemberger, R. Pišot, & K. Rupret (Eds.) *Proceedings 5th International Symposium A Child in Motion "The physical education related to the qualitative education"* (pp. 496–501). Koper: University of Primorska, Faculty of Education Koper, Science and research centre of Koper; Ljubljana: University of Ljubljana, Faculty of Education.

Škof, B., Cecić Erpič, S., Zabukovec, V., & Boben, D. (2002). Pupils' attitudes toward endurance sports activities. In D. Prot, & F. Prot (Eds.), *Kinesiology – new perspectives*, 3rd International scientific conference (pp. 137–140), Opatija: University of Zagreb, Faculty of Kinesiology.

4. Manuscript submission

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