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TABLE OF CONTENTS

EDITORIAL

How to take advantage of information technology in favour of the exercise / sports activity is a challenge, addressed not only by the manufacturers of sports equipment and technologies but also all the sports professionals who strive to move the curve of the decline in locomotor activity in a positive direction. The questions of how to exploit actively the benefits of tennis video games for the young tennis players are also posed by the authors of the first article that have found positive effects especially in the improvement of visual attention, which, however, cannot replace the real training techniques. The following article reminds us of how important regular physical / sports activity in college years is, which also demonstrates a positive connection between longer and more intense physical exercising and academic achievement. At the same time, the article indicates that a quarter of students in Slovenia still do not reach the recommended levels of sports activities.

In a conference at the 70th anniversary of Prof. Carlo Reggiani, Ph.D., we together celebrated the treasure trove of his contributions. The lecturers introduced many new findings and facts, and again highlighted the importance of expertise in the field of skeletal muscles physiology. The next contribution with a similar topic presents the positive effects of electrical stimulation on muscle contraction and, consequently, different adaptations that derive from the procedure. The following article discusses regular physical activity which has become the guarantee for a healthy life and maintaining functional ability in old age. The article highlights the positive effects of an active lifestyle in order to prevent and reduce the problems of the decreasing mental health of the elderly as the most vulnerable groups.

The red thread of scientific and expert conference »Motor Skills of Children« and the first international summer school »Healthy and Active Lifestyle« was the importance of acquiring and mastering movement skills in childhood which seems to be one's physical capital, leading to an active and healthy life style in all life periods. The conference marking the World Food Day 2018 reminded of healthy diet guidelines and confirmed that both movement and healthy nutrition are integral parts of a healthy life style and they simply cannot and should not be treated separately.

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

UVODNIK

Kako izkoristiti informacijsko tehnologijo v prid gibalni/športni aktivnosti je izziv, ki si ga postavljajo ne samo proizvajalci športne opreme in tehnologij, temveč tudi vsi tisti športni strokovnjaki, ki stremijo za ciljem premakniti krivuljo upada gibalne aktivnosti v pozitivno smer. Vprašanje, kako izkoristiti aktivno video igro tenisa pri mlajših teniških igralcih, so si tako zastavili tudi avtorji prvega članka in ugotovili pozitivne učinke predvsem v izboljšanju vizualne pozornosti, ki pa ne more nadomestiti realnega treninga tehnike. Kako pomembna je redna gibalna/športna aktivnost v študentskih letih, nas opozarja naslednji članek, ki ravno tako dokazuje pozitivno povezanost daljše in intenzivnejše vadbe s telesnim fitnesom in študijskim uspehom, obenem pa opozarja na to, da še vedno četrtina študentov v Sloveniji ne dosega priporočljive stopnje gibalne/športne aktivnosti.

Bogata je zakladnica znanja, ki smo jo udeleženci obeležili na konferenci ob 70-letnici prof. dr. Carla Reggianija na Univerzi v Padovi. Prisotni referenti in ostali so predstavili številna nova znanja in dejstva ter znova opozorili, kako pomembna so temeljna poznavanja področja fiziologije skeletnih mišic. Podobno tematiko obravnava tudi prispevek, v katerem avtorji predstavijo pozitivne učinke električne stimulacije na mišično kontrakcijo in posledično njene adaptacije. Da je redna gibalna aktivnost postala garancija zdravega življenja in ohranjanja funkcionalnih sposobnosti tudi v starosti, govori naslednji pregledni članek, v katerem so poudarjeni pozitivni učinki aktivnega življenjskega sloga v preventivi in zmanjševanju problemov upadanja mentalnega zdravja starostnikov kot najbolj ranljive skupine.

Pomen pridobivanja in usvajanja gibalnih kompetenc v otroštvu kot gibalnega kapitala, ki vodi v aktiven in zdrav življenjski slog skozi vsa obdobja, pa je predstavljal rdečo nit znanstvene in strokovne konference »Motorička znanja djece« ter prve mednarodne poletne šole »Healthy and Active Lifestyle«. Poleg smernic zdrave prehrane, ki so bile predstavljene na konferenci ob svetovnem dnevu hrane 2018, so udeleženci konference ponovno potrdili, da sta gibanje in zdrava prehrana neločljiv tandem zdravega življenjske sloga in ju enostavno ne moremo in ne smemo obravnavati ločeno!

prof. dr. Rado Pišot,
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PLAYING ACTIVE VIDEO GAMES WHILE IN A TENNIS TRAINING PROCESS: A NEW TRAINING TOOL OR A HANDICAP FOR CHILDREN?

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ABSTRACT

Aim: *The purpose of this pilot study was to quantify the effect of a continued active video games (AVG) playing on the tennis forehand and backhand technique development.*

Methods: *Altogether 24 tennis players (7 – 9 year olds) were randomly divided in two different groups, both involved in a 12-week tennis training program (twice a week for an hour). The participants in the experimental group received an additional twice a week (20-minute) AVG Virtua Tennis 4 game intervention at the end of each regular tennis training hour, while the participants in the control group received no additional intervention. Pre- and post-AVG intervention, the Tennis Rating Score for Children scale (TRSC) was applied to detect tennis training-related changes that occur in each specific stroke.*

Results: *Our results at the post-test show that participants in the experimental group did not significantly improved in one element (TRSC12; p = 0,317) in the forehand stroke and two (TRSC10; p = 0,157 and TRSC12 p = 0,157) in the backhand. The control group significantly improved in all the fifteen evaluated elements in both the forehand and backhand stroke. The experimental group had a higher effect size in*

all the kinetic chain section in both the forehand and backhand stroke compared to the control. The same happens for the TRSC7 (point of contact – height).

Conclusion: *Prolonged AVG playing seems to improve visual attentions skills (perception of a moving object) in young tennis players, giving them the opportunity to be able to prepare themselves for the oncoming ball sooner as compared to their control counterparts. From the other perspective, AVG were shown to negatively affect correct players positioning, especially at the beginning and at the end of a stroke.*

Keywords: *exergames, tennis technique, visual attention skills.*

IGRANJE AKTIVNIH VIDEO IGER V PROCESU UČENJA TENISA OTROK: NOVO VADBENO ORODJE ALI OVIRA?

IZVLEČEK

Cilj: *Namen pilotske študije je bil preučiti vpliv dolgotrajnega igranja aktivnih video iger (AVG) na proces usvojitve tehnike teniških udarcev bekend in forhend.*

Metode: *V študiji je sodelovalo 24 teniških igralcev starih 7 do 9 let, ki so bili naključno razdeljeni v dve skupini. Obe skupini sta bili vključeni v 12-tedenski teniški program usposabljanja (dvakrat na teden po eno uro). V prvi, t. i. eksperimentalni skupini, so igralci poleg rednega procesa treninga, bili deležni 20 minutnega igranja AVG Virtua Tennis 4 neposredno po treningu. Kontrolna skupina se je udeleževala le rednega procesa treninga. Za oceno izvedbe tehnike udarcev smo uporabili lestvico teniškega napredka (TRSC).*

Rezultati: *Po 12-tedenski intervenciji eksperimentalna skupina ni pomembno napredovala v enem elementu (TRSC12; p=0,317) pri forhend udarcu in dveh (TRSC10; p=0,157 in TRSC12; p=0,157) pri bekend. Kontrolna skupina je pomembno napredovala v vseh petnajstih elementih tako pri forhend kot bekend udarcu. Eksperimentalna skupina je imela višjo vrednost učinka pri vseh elementih kinetične verige tako pri bekend kot forhend udarcu v primerjavi s kontrolno skupino. Enako velja za element TRSC7 (višina točke udarca).*

Zaključek: *Dolgotrajno igranje AVG naj bi izboljšalo vidno zaznavne sposobnosti mladih teniških igralcev in s tem omogočilo hitrejšo postavitev na udarec. Po drugi strani negativno vpliva na pravilno tehnično postavitev in zamah pri forhend in bekend udarcih. Rezultati predstavljajo koristne informacije tako za starše kot trenerje o vplivu AVG na teniški razvoj mladih igralcev.*

Ključne besede: *aktivne video igre, tehnika udarcev, vidno prostorske sposobnosti.*

INTRODUCTION

Active video games (hereinafter AVG) represent a new video games generation that introduced controllers and motion sensing input devices, for which a whole body physical interaction is required while playing (Mears & Hansen, 2009). Compared to the traditional sedentary video games, the new virtual reality experience allowed its users to see, hear and feel the environment as being part of it. AVG are able to track full-body movements in three dimensions, can measure reaction times, accelerations and detect the speed of a player's movement (Staiano & Calvert, 2011). While playing, the users need to simulate the basic movements and features that represent the key elements and specificities of each sport, hence they are able to express the most authentic replication of a real sport experience.

The most popular AVG devices are the commercially available Xbox, Wii, and PlayStation consoles. According to Fulton et al. (2012), 40 % of adolescents play video games at least once a week, 83 % of Americans aged between 8 and 18 have at least one AVG console at home while 56 % have two or more (Rideout, Foehr & Roberts, 2010).

The fast growing interest in AVG made them a significant research area. Studies were mainly focused on the contribution they can offer as a weapon against sedentary lifestyle and a way to promote wellness. Review articles and meta-analysis for observational studies (Peng, Lin & Crouse, 2011; Peng, Crouse & Lin, 2013) proved that playing AVG compared to inactivity, increase heart rate, oxygen consumption (VO2) and energy expenditure. Even more recent studies (Newel, 2013; Mills et al. 2013) demonstrate that a critical threshold of 3 METs (Metabolic Equivalents), representing moderate activities (3.5 to 7 kcal / min), can be achieved while playing AVG. According to the above-mentioned studies, playing AVG increases physiological body responses. The unexplained field remains the influence of those games on the development of motor abilities and fundamental movement skills (Barnett, Hinkley, Okely, Hesketh & Salmon, 2012), which provide the basis for a more successful performance of sport-specific movement skills (Lubans, Morgan, Cliff, Barnett & Okely, 2010). Furthermore, few studies have been conducted on children using AVG and none on tennis.

Since 2007, the Physical Activity Council (2016) reports a 6 % increase in tennis players, which is the highest increment among all analyzed sports. Currently, nearly 4000 young professional tennis players (< 19 years old) are listed in the International Tennis Federation (ITF). Due to the fast growing number of professional tennis players across the world and the subsequent increasing competitiveness, the intensity and volume of training programs have been led to a higher level in early ages, intended to reach superior results (Reid, Crespo & Santilli, 2009). In accordance with the International Tennis Federation Coaches' Education Program (Crespo & Reid, 2009), 6 to 12-year-old children represent the Introduction / Foundation stage in a tennis world class players' development guidelines, with the main goal of fully mastering the technique of basic strokes (forehand, backhand, serve). All the distinct phases of a player development are inextricably linked together (Saviano, 2001) and without successfully acquired fundamentals (technique of basic strokes), the increasing intensity

and volume of training sessions, which are enhanced in the second phase, may lead to injuries.

As AVG are mainly used among adolescents, when the development of motor skills is in full swing, determining their positive and negative effects may offer the prospect of a possible application using them in favor of improving physical performance by their influence on motor efficiency and learning. On the other side, repetitive performance of irregular movement patterns may destroy the correct execution of the strokes that were previously learned during the training sessions. Therefore, the aim of our study was to evaluate the impact of a continued AVG playing on the tennis technique development during the training process in 7- to 9-year-old children.

METHODS

Participants

This research was conducted on 24 tennis players (7 females, 17 males, average age 7.95 ± 0.92 years, range 7 – 9 year olds) recruited from the local tennis club (Tennis Club Portorož, Slovenia, EU). After a detailed presentation of the study, its purpose, and study design to the participants and parents, we obtained a written parental consent for each child. The inclusion criterion was no more than two years of regular participation in a tennis training process; players with injuries or long-term body impairments that prevented them from performing shots as they are usually instructed were excluded. The study was approved by the Republic of Slovenia National Medical Ethics Committee, number 0120-631/2017/2.

Study Design

The participants were randomly allocated into experimental (tennis training + AVG; 11 participants; female: 3; male: 7) and control (only tennis training; 13 participants; female: 1; male: 12) group. Both groups attended a 12-week tennis training program (twice a week for an hour), where the experimental group had an additional AVG intervention which lasted 20 min per session and was administred after each "physical" tennis training. For AVG, the Virtua Tennis 4 game on Xbox 360 console was chosen. We used the kinect device that allowed the participants to play using merely the movements of their body.

The children were involved in a novice tennis training program where each training session lasted for one hour, with an emphasis on tennis strokes technique execution and motor skills development (agility, balance, coordination, power, reaction time and speed). The AVG intervention program was implemented to be able to gradually increase the difficulty of the game. The game itself provides different levels of difficulty for "human player vs. computer option", as well as an option to play with "multiple

human players". For our intervention, both options were chosen depending on the number of children involved and mixed troughout the whole interventional period. The participants with an absence percentage up to 15 (more than 3 times) were eliminated from the investigation.

Outcome Measures

Our participants are novice tennis players, therefore, as stated in the introduction, their main goal is to fully master the technique of main strokes. For assessing the progress made in the game of tennis, we used the TRSC that evaluates the improvement made in technique of both the forehand and backhand stroke. We decided not to assess the serve stroke, as the children up to 9 years of age who have not yet developed enough power for such a complex movement play the stroke only in its most basic version. The scale divides each stroke in fifteen different elements that need to be evaluated to reach the final score. We followed the protocol which had previously been validated in Šlosar, Šimunic, Pišot & Marusic, (2018). The TRSC is divided into fifteen different elements (Figure 1) that need to be evaluated to reach the final score, i.e. the current technical knowledge in a specific stroke. The elements correspond to different postitions end motions starting from the stroke preparation to a follow-through and the kinetic chain, that all evaluate the coordinated activation of all body segments involved (for details see Šlosar, Šimunic, Pišot & Marusic, 2018). The evaluation needs to be performed while reviewing the execution previously recorded on a video tape with the possibility of viewing it in slow motion and pausing the recording at the desired player position. Video clips were made using high quality video facilities on mobile phones and free computer applications for editing. All the evaluated elements were rated on 5-point grading Likert scale.

Table 1. Tennis rating score for children evaluation criteria.

SHOT PREPARATION	**ARM POSITION**	**BACKSWING**	**STANCE**
FOREHAND	The non-hitting hand leads the racket head to the back swing and going to extend out to the side of the court in a parallel position to the ground. The hitting hand should be slightly bent at the back while holding the racket vertically with the butt-cap facing the court.	Shoulder rotation until they are perpendicular to the net with hips "locked" at the pelvic joint.	Weight is on the rear leg with knees bent and foot pointing out. Front leg in the game direction.
BACKHAND	Both hands are at the back of the body with the hitting arm straight and the other slightly bent. An "L" shape must be created with the arm and racquet position.	Shoulder rotation until they are perpendicular to the net with hips "locked" at the pelvic joint.	Weight is on the rear leg with knees bent and foot pointing out. Front leg in the game direction.
ACCELERATION	**WEIGHT TRANSFER**	**HITTING MOTION**	**RACQUET PATH**
FOREHAND	Shot preparation: 80 % rear leg; 20 % front leg. Contact point: 50 % rear leg; 50 % front leg. The center of gravity is raised within the trunk, by transferring the body weight forward.	Hips and shoulders rotate forward and open up towards the court.	Leaning forward at the bottom of the swing. The butt-cap is pointing to the net with the wrist taken back creating pre-stretch. The racquet then accelerates upward and forward.
BACKHAND	Shot preparation: 80 % rear leg; 20 % front leg. Contact point: 50 % rear leg; 50 % front leg. The center of gravity is raised within the trunk, by transferring the body weight forward.	Hips and shoulders rotate forward and open up towards the court.	Leaning forward in the bottom of the swing. The butt-cap is pointing to the net with the wrists taken back creating pre-stretch. The racquet then accelerates upward and forward.

POINT OF CONTACT	HEIGHT	BODY POSITION	SWEET SPOT
FOREHAND	In front of the body at the hip level.	Low center of gravity with legs at least shoulder-width apart. Shoulders must be parallel to the net with an upright and still head position.	Close to the center of the racket.
BACKHAND	In front of the body at the hip level.	Low center of gravity with legs at least shoulder-width apart. Shoulders must be parallel to the net with an upright and still head position.	Close to the center of the racket.
FOLLOW THROUGH	**END POSITION**	**RACQUET POSITION**	**NON-DOMINANT ARM POSITION**
FOREHAND	Above the non-hitting arm shoulder.	The racquet faces horizontally at completion.	Tucked at the side of the body or used to catch the racket at the final position.
BACKHAND	Above the shoulder of the hand placed at the bottom of the grip.	The racquet faces horizontally at completion.	Bent to an "L" shape, keeping the elbow up before finishing the follow-through (right arm – for right-handers).
KINETIC CHAIN	**SEQUENCE OF ACTIVATED BODY SEGMENTS**	**FLUIDITY**	**TIMING**
FOREHAND	Legs (extension through ankles, knees, and hips), hips (rotation), trunk (rotation), shoulder (horizontal adduction and internal rotation), forearm (pronation), wrist (flexion).	A soft, simple and rhythmic swing that flows through the stroke, without being affected by the ball's presence.	Make motions and put themselves in right body positions at the right moment to match parts of the stroke that belong together.
BACKHAND	Legs (extension through ankles, knees, and hips), hips (rotation), trunk (rotation), shoulder (horizontal abduction and external rotation), forearm (supination), wrist (extension).	A soft, simple and rhythmic swing that flows through the stroke, without being affected by the ball's presence.	Make motions and put themselves in right body positions at the right moment to match parts of the stroke that belong together.

Procedure

The evaluation was performed by the participants' tennis coach. All the participants were evaluated on a forehand and backhand stroke on Day 1 and Day 84 (pre- and post-intervention). To better understand the influence of a continued AVG playing on a tennis technique, only the results corresponding to fifteen evaluated elements were considered, while the final TRSC score is primarly used to make the data analysis more comprehensible, especially for the players' parents.

Statistical Analysis

The distribution of each evaluated element (TRSC scale) was examined on a normal quantile (Q-Q) plot as well as a histogram to determine whether the data were well approximated by a normal (Gaussian) distribution. Non-normally distributed data were summarized with means and standard deviations. The results between the control and experimental group at the pre-test were compared using the Mann Whitney U-test. Differences between pre- and post-test for the control and experimental group were evaluated with a Wilcoxon test. The intervention effect size was estimated and interpreted by Cohen (1988) as follows: > 0.1 small; > 0.3 medium; > 0.5 large effect.

A p value < 0.05 was considered statistically significant.

RESULTS

All the participants from the initially included 24 were taken into statistical analyses. The data from all fifteen elements of the TRSC were non-normally distributed ($p < 0.05$). Mann Whitney test showed no significant differences for both the forehand and backhand stroke between the experimental and control group at the pre-test. Table 1 shows the baseline characteristics of the children included.

Table 2. Characteristics of included children.

	Experimental group		Control group	
	M	**SD**	**M**	**SD**
Experience (months)	15	0.72	17	0.71
Age	7.43	0.82	8.38	0.96
Height	130.73	9.43	141.00	9.16
Weight	27.18	4.6	35.85	6.28

Forehand

A Wilcoxon test revealed a significant improvement at the post-test for all the fifteen evaluated elements in the control group. A moderate effect size was shown in TRSC7 (0.42) and TRSC9 (0.46). In all the other elements, the effect was large and greater than 0.52. At the post-test, the experimental group did not significantly improve in TRSC12 (p = 0.317). The same element revealed a low effect size (0.21). A moderate effect size was shown in TRSC1 (0.43) and TRSC10 (0.48). In all the other elements, the effect size was large and greater than 0.52.

Table 3. Wilcoxon test between the pre and post-test for the experimental and control group for the forehand stroke.

	Control group			Experimental group		
TRSC	**Pre-test**	**Post-test**	**P (ES)**	**Pre-test**	**Post-test**	**P (ES)**
1	2.69 ± 0.48	3.54 ± 0.66	0,001 (0,64)	2.09 ± 0.70	2.27 ± 0.47	0,046 (0,43)
2	2.54 ± 0.97	2.85 ± 0.55	0,001 (0,66)	2.27 ± 0.79	2.82 ± 0.40	0,011 (0,54)
3	2.31 ± 0.86	2.92 ± 1.25	< 0,001 (0,69)	2.00 ± 0.63	2.45 ± 1.03	0,002 (0,67)
4	2.38 ± 0.77	2.38 ± 0.77	< 0,001 (0,71)	2.09 ± 0.70	2.09 ± 0.70	0,003 (0,64)
5	2.23 ± 0.83	2.77 ± 0.56	0,002 (0,60)	2.18 ± 0.75	2.73 ± 0.47	0,003 (0,64)
6	2.00 ± 0.70	2.62 ± 0.65	0,004 (0,57)	1.82 ± 0.40	2.27 ± 0.78	0,002 (0,65)
7	2.54 ± 0.78	2.85 ± 0.69	0,034 (0,42)	2.27 ± 0.79	3.45 ± 0.52	0,002 (0,64)
8	2.31 ± 0.75	2.31 ± 0.75	0,005 (0,55)	2.09 ± 0.70	2.09 ± 0.70	0,005 (0,60)
9	3.00 ± 1.08	3.31 ± 0.75	0,020 (0,46)	2.45 ± 1.03	3.00 ± 0.63	0,011 (0,54)
10	2.85 ± 0.99	3.08 ± 0.86	0,004 (0,57)	2.82 ± 0.98	3.18 ± 0.75	0,025 (0,48)
11	2.38 ± 0.77	3.08 ± 0.64	0,001 (0,64)	1.91 ± 0.83	2.45 ± 0.69	0,014 (0,52)
12	2.85 ± 0.55	3.38 ± 0.77	0,005 (0,55)	2.82 ± 0.40	2.82 ± 0.40	0,317 (0,21)*
13	2.54 ± 0.78	2.62 ± 0.65	0,008 (0,52)	2.27 ± 0.79	2.45 ± 0.52	0,003 (0,63)
14	2.23 ± 0.73	2.69 ± 0.48	0,001 (0,65)	2.00 ± 0.63	3.00 ± 0.63	0,002 (0,67)
15	2.00 ± 0.58	2.31 ± 0.75	0,003 (0,59)	1.82 ± 0.40	3.00 ± 0.48	0,002 (0,67)

Notes: ES = effect size; * p > 0,05

Backhand

A Wilcoxon test revealed a significant improvement at the post-test for all the fifteen evaluated elements in the control group. A moderate effect size was shown in TRSC7 (0.44). In all the other elements, the effect was large and greater than 0.53. At the post-test the experimental group did not significantly improve in TRSC10 (0.157) and TRSC12 (p = 0.157). The same elements revealed a moderate effect size (0.30), as it is for TRSC1 (0.48), TRSC8 (0.30) and TRSC9 (0.43). In all the other elements, the effect size was large and greater than 0.58.

Table 4. Wilcoxon test between the pre and post-test for the experimental and control group for the backhand stroke.

	Control group			Experimental group		
TRSC	**Pre-test**	**Post-test**	**P (ES)**	**Pre-test**	**Post-test**	**P (ES)**
1	2.38 ± 0.77	3.08 ± 0.64	0,001 (0,65)	2.18 ± 0.60	2.36 ± 0.67	0,025 (0,48)
2	2.00 ± 0.82	2.31 ± 0.63	0,001 (0,63)	2.18 ± 0.75	2.45 ± 0.52	0,005 (0,60)
3	1.85 ± 0.69	2.62 ± 0.87	0,001 (0,64)	1.45 ± 0.52	2.27 ± 0.79	0,001 (0,68)
4	2.23 ± 0.83	2.31 ± 0.75	0,001 (0,64)	2.00 ± 0.63	2.00 ± 0.63	0,007 (0,58)
5	1.85 ± 0.55	2.62 ± 0.51	0,001 (0,63)	1.91 ± 0.54	2.91 ± 0.54	0,002 (0,67)
6	1.85 ± 0.69	2.08 ± 0.64	0,001 (0,65)	2.00 ± 0.63	2.00 ± 0.63	0,008 (0,64)
7	2.46 ± 0.78	2.62 ± 0.51	0,025 (0,44)	2.36 ± 0.67	3.45 ± 0.52	0,002 (0,58)
8	2.00 ± 0.82	2.15 ± 0.89	0,001 (0,63)	2.00 ± 0.63	2.00 ± 0.63	0,003 (0,30)
9	2.54 ± 0.78	3.08 ± 0.64	0,003 (0,58)	2.27 ± 0.78	2.82 ± 0.40	0,007 (0,43)
10	2.54 ± 0.78	2.77 ± 0.44	0,001 (0,67)	2.64 ± 0.80	2.82 ± 0.40	0,157 (0,30)*
11	2.31 ± 0.75	2.92 ± 1.04	0,001 (0,64)	1.73 ± 0.78	1.82 ± 0.75	0,046 (0,63)
12	2.54 ± 0.78	2.92 ± 0.49	0,001 (0,63)	2.64 ± 0.80	2.64 ± 0.81	0,157 (0,30)*
13	2.31 ± 0.75	2.46 ± 0.52	0,007 (0,53)	2.18 ±0.75	2.36 ± 0.50	0,003 (0,63)
14	1.77 ± 0.44	2.38 ± 0.76	< 0,001 (0,69)	1.82 ± 0.40	2.82 ± 0.40	0,001 (0,71)
15	1.92 ± 0.49	2.15 ± 0.68	0,002 (0,62)	1.82 ± 0.40	3.00 ± 0.48	0,001 (0,68)

Notes: ES = effect size; * p > 0,05

DISCUSSION

The aim of the present pilot study was to evaluate the impact of a prolonged AVG playing on the tennis technique of two main strokes while being in a tennis training process. Our results show similar intervention effects among both the forehand and backhand stroke. The evaluated TRSC12element has not been improved by the experimental group in both the forehand and backhand stroke. The same stands for the TRSC10 element only in the backhand stroke. As part of the follow-through sections, prolonged AVG playing seems to negatively affect a proper player positioning at the end of the stroke. A poorer attention at the correct tennis positions is also noted comparing the effect size among groups at the TRSC1, which stands for the arm position at the shot preparation. In both the backhand and forehand stroke, the stroke is large in the control group and moderate in the experimental. The results may find explanation upon the model of control the user had over the actions of the avatar in AVG, which are more prominent on simple reaction times and timing of the hand swing. If the hand does not swing at the right time, the avatar would fail to shoot the ball, which is not considered to be a successful stroke in this model.

The whole kinetic chain section (the sequence of activated body segments; fluidity; timing), is the only one among both strokes where the experimental group had a higher effect size. The TRSC13 element (the sequence of activated body segments) had a large effect size in the experimental group compared to the moderate in the control. The same happens with the TRSC7 element (point of contact – height) in both strokes. The results may suggest that AVG might increase a player's reaction time and attention towards the ball arriving from the other side of the court. The results seem to confirm the ones concluded by Green and Bavelier (2003; 2006) which demonstrate higher visual attention skills in video game players compared to non-players. Improved visual attention skills represent the ability to track objects moving at a higher speed, track multiple items at the same time, eliminate irrelevant visible information, increase focusing and concentration capabilities.

The constant technology development managed to create natural user interfaces and gesture recognition video game consoles which are able to track full-body movements in three dimensions, thus offering the opportunity to play virtual sports as being in a real environment. The results of the present study support Wiemeyer & Kliem (2012) theories, asserting that, due to the way of playing some motor control competencies may be enhanced, such as: reaction time, balance, endurance, strength and rhythmic abilities. Furthermore, Wiemeyer & Hardy (2013) in accordance with our results, confirmed that a possible transfer of motor learning settings between the real and virtual environment may be possible while using AVG.

To our knowledge, this is the first study that evaluates the effects of prolonged AVG playing on specific sport technique execution and not performance. Several limitations are however acknowledged in the study, starting from the lack of a third group playing just AVG without any real tennis practice and the small sample size used. Furthermore, a combination of technical and precision skills (suitable for beginners) would extend

the range of knowledge about AVG. Finally, we cannot generalize results among the entire middle age population, as they are related to participants with a specific status, like children from wealthy families, or those with high expectations of accomplishment. Although the findings of this pilot study do suggest that a possible transfer of motor learning settings between the real and virtual environment may be possible, this still needs to be addressed on larger samples.

CONCLUSION

On the basis of the above, as many AVG like the Virtua Tennis 4 require rapid movements, they may improve general visual attention skills. On the other side, they can negatively affect correct technique positioning. The results of our study suggest a specific adaptation of playing AVG while being in the tennis process. Namely, 7- to 9-year-old children who play AVG (Virtua Tennis 4) twice a week for three months (24 x AVG + tennis trainings) are more progressive in cognitive domain, while having negative adaptation from the perspective of tennis technique acquisition (the first and the last part of a stroke motion). The present study shows the effect of playing / not playing AVG in children while being in the early process of tennis training program, and better understand the impact of AVG games on players' physical skills. Finally, the results of our pilot study, the first of its kind, could serve as – a scientific evidence noting to which extent playing AVG influences the tennis technique.

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PHYSICAL ACTIVITY OF UNIVERSITY STUDENTS AND ITS RELATION TO PHYSICAL FITNESS AND ACADEMIC SUCCESS

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ABSTRACT

Introduction: *The purpose of this study was to determine the physical activity performed by students, its frequency and intensity and how this physical activity may relate to their physical fitness and academic success.*

Methods: *The sample consisted of 297 undergraduate students from 20 to 22 years of age (mean 20.5 ± 0.7) from the University of Maribor. The type and frequency of physical activity in which they engaged were measured using the IPAQ. Academic performance was defined as regular admission to the second year of study. Students' physical fitness was determined using Eurofit and FitnessGram tests.*

Results: *Analysis of the IPAQ questionnaire shows that the majority of students reported being physically active in the afternoon. Nevertheless, according to the WHO's guidelines, 79.8 % of students were insufficiently physically active. The results show that males performed better than females in nearly all of the physical fitness tests. Periods of two to three hours of weekly physical activity were positively associated with academic success, while four hours or more resulted in no contribution.*

Conclusion: *Correlations between physical activity and physical fitness were primarily found in higher duration physical activity and in higher frequency of vigorous exercise. The results of this study are similar to those of other countries regarding the*

insufficient physical activity of young people. The influence of physical activity on academic success was analyzed by binary logistic regression. The majority of students were academically successful and regularly admitted to the second year of study (86.5 %).

Keywords: *physical activity, physical fitness, academic achievement, university students.*

TELESNA DEJAVNOST ŠTUDENTOV IN NJENA POVEZAVA S TELESNIM FITNESOM IN ŠTUDIJSKIM USPEHOM

IZVLEČEK

Namen: *Cilj raziskave je bil ugotoviti pogostost in intenzivnost izvedene telesne aktivnosti študentov ter kako ta telesna aktivnost vpliva na njihovo telesno kondicijo in študijski uspeh.*

Metode: *V vzorec merjencev je bilo zajetih 297 dodiplomskih študentov in študentk starih od 20 do 22 let (AS 20.5±0.7) Univerze v Mariboru. Vrste in pogostost telesne aktivnosti smo merili z IPAQ vprašalnikom. Akademska uspešnost študentov je bila ocenjena z rednim napredovanjem v drugi letnik študija. Telesna pripravljenost študentov je bila ocenjevana z uporabo Eurofit in FitnessGram baterijo testov.*

Rezultati: *Rezultati analize IPAQ vprašalnika kažejo na to, da so študentje telesno aktivni večinoma v popoldanskih urah. V skladu s smernicami Svetovne zdravstvene organizacije (WHO) je kar 79,8% študentov neaktivnih ali premalo telesno aktivnih. Rezultati nam kažejo, da moški v skoraj vseh testih telesne pripravljenosti dosegajo boljše rezultate kot ženske. Dve do tri ure telesne aktivnosti na teden kaže pozitiven učinek na študijski uspeh, medtem ko pri štirih urah in več tedenske aktivnosti, tega učinka ni zaznati.*

Zaključek: *Korelacija med telesno aktivnostjo in telesno kondicijo je bila ugotovljena predvsem ob daljšem trajanju telesne aktivnosti ter pogostosti naporne vadbe. Rezultati te študije so bili podobni študijam v drugih državah, kjer so ugotovili premajhno telesno aktivnost mladih. Vpliv telesne aktivnosti na študijski uspeh je bil analiziran z binarno logistično regresijo. Večina študentov je bila akademsko uspešnih (86,5%) in je redno napredovala v drugi letnik študija.*

Ključne besede*: športna aktivnost, telesna pripravljenost, študijski uspeh, študenti.*

INTRODUCTION

Past research studies confirm that regular physical activity performed by children, adolescents and adults has a positive effect on health (Boreham & Roddoch, 2001; Pori et al., 2013) and reduces the risk of developing various diseases (Hallal, Victora, Azevedo & Wells, 2006; Warburton, Nicol & Bredin, 2006). Generally, physical fitness and physical activity excerpt a positive impact on perception and concentration (Centers for Disease Control and Prevention, 2010; Trudeau & Shephard, 2008). Additionally, consistent physical activity has a positive influence on self-esteem (Crocker, Sabiston, Kowalski, McDonough & Kowalski, 2006; Dunton, Jamner & Cooper, 2003; Moreno, Cervelló & Moreno, 2008; Weiss & Williams, 2004), while lowering anxiety and stress (Dolenc, 2015; Flook, Repetti & Ullman, 2005). However, it must be taken into account that vigorous physical activity is time-consuming, requires recovery and therefore might reduce learning and studying time. The extended use of the internet and computer games (i.e., screen-time) poses a huge threat to a healthy lifestyle; therefore, only a small proportion of adolescents regularly participate in physical activity (Aslan & Arslan Cansever, 2012; Madell & Muncer, 2004).

Many studies have attempted to identify a relationship between physical activity and academic achievement. However, these studies have had diverse and even contradictory conclusions: a significant positive correlation between the duration of physical activity and academic success (Coe, Pivarnik, Womack, Reeves & Malina, 2006; Kim et al., 2003), small correlation between them (Daley & Ryan, 2000; Sallis et al., 1999) and a negative correlation (Tremblay, Inman & Williams, 2000). Research has also established that physical activity itself has many positive effects (better self-image, self-esteem, behavioural changes, better motivation in other areas, etc.), all of which influence academic success (Trudeau & Shephard, 2008).

In the literature, the FitnessGram assessment was primarily used in the USA (Renfrow, Caputo, Otto, Farley & Eveland-Sayers, 2011; Shriver et al., 2011). In Europe, for example, fitness tests were usually combined with FitnessGram and Eurofit items alongside some national recommendations (Aires et al., 2010). Recent results of health-related fitness tests on children show that results are progressively worsening and are accompanied by growing obesity and low physical activity (Shriver et al., 2011). A comparison between obesity and health-related fitness is easier to conduct because the measures are well-defined, whereas physical activity can be measured by various means, for example, by weekly duration, frequency, intensity or variety.

The study of physical activity of the university student population is especially interesting, as in Slovenia and several other countries (Cardinal, Sorensen & Cardinal, 2012; Hardman, 2008), physical education is no longer a mandatory subject at tertiary level, as it is in secondary schools. Therefore, it is important to establish if one of the most important objectives of mandatory physical education, i.e., educating students to accept physical activity as one of their regular life-long habits, has actually been fulfilled and if the decision to drop physical education from university curricula, a decision

made several years ago, has resulted in a large proportion of students becoming insufficiently active or even inactive.

The aim of our study was twofold: 1) to explore the current state of physical activity and the physical fitness of university students and their anthropometric data and 2) to explore the relationship between physical activity, physical fitness and the academic success of university students. There has been little research on the effect of physical activity on academic performance in Slovenia. On the basis of research results elsewhere, we assume that our study will demonstrate the positive effects of physical activity on academic performance.

METHODS

Sample

The sample consisted of second-year undergraduate students from fourteen faculties of the University of Maribor. Approximately 10 % of all full-time second-year undergraduate students, between 20 and 22 (mean 20.5 ± 0.7) years of age, agreed to participate in the study (n = 297, 114 or 38.4 % males and 183 or 61.6 % females).

Data Collection Procedure

To collect information about students' physical activities in the week before fitness testing, we used the IPAQ questionnaire (Bailey, Mckay, Mirwald, Crocker & Faulkner, 1999) with certain modifications (questions about the time of day and the type of physical activities were added). The time aspect of physical activity execution is divided as follows: pre-noon physical activities happen before 12 o'clock, afternoon physical activities are performed between 12 and 6 pm, while evening physical activities are executed after 6 pm and later. Physical fitness testing took place at the University Sports Centre and was carried out by staff trained in measurement procedures. The two-day testing was open to all second-year students at the University of Maribor. Participation was voluntary; all of the participants gave written consent. Individual fitness tests were carried out at stations set up as a polygon. The order of fitness tests and conducted measurements were the same for all participants. We administered the following twelve physical fitness test items to measure motor performance FitnessGram (Meredith & Welk, 2010), EuroFit (Topend Sports, 2016) and national recommendations SLOFit (Strel et al., 1996): plate tapping test (20"), polygon backwards, the wall toss test, standing forward bend and reach flexibility test, sit and reach flexibility test, standing shoulder rotation flexibility test, standing long jump test, sit-ups in 60" test, flexed arm hang test, the flamingo balance test, 20-meter sprint and the 20-meter shuttle run. The 20-meter shuttle run results were converted to VO2 max volumes according to the instructions set out by Ramsbottom et al. (1988). The following anthropometric measures

were taken (Topend Sports, 2016): body height, body weight, upper arm circumference, thigh circumference and abdominal circumference. To estimate the amount of subcutaneous fat, we measured each participant's upper arm (triceps) skinfold, thigh skinfold (suprapatellar), abdomen skinfold (abdominal and suprailiac skinfold) and back skinfold.

The weekly duration of physical activity (number of hours of physical activity in the previous week), frequency of vigorous physical activity (number of sessions of vigorous physical activity lasting at least 15 minutes in the previous week), frequency of moderate physical activity (number of sessions of moderate physical activity lasting at least 15 minutes in the previous week), frequency of low effort physical activity (number of sessions of low effort physical activity lasting at least 15 minutes in the previous week) and sports club membership were used as indicators of physical activity. Criteria suggested by Janssen (2001) were employed to measure the intensity of physical activity (vigorous, moderate, low effort).

The dependent variable of academic success was defined as the regular admission to the second year of study (coded as 1 if a student was regularly admitted from the first to the second year of study and 0 otherwise).

Data Analysis

The collected data were analyzed using IBM SPSS 20.0 software (IBM Corp., Armonk, NY). Physical fitness test results were compared by gender using an independent samples t-test or Mann-Whitney U test in case the Shapiro–Wilks test did not confirm the normal distribution of data. To determine the relationship between physical activity and physical fitness tests, Spearman's correlation coefficient was used. The influence of physical activity on academic success was calculated by a binary logistic regression. The odds ratio, 95 % confidence interval and *P* value were calculated for each variable included in the logistic model. A $P < 0.05$ was considered statistically significant.

RESULTS

Analysis of the IPAQ questionnaire results shows that the majority of students reported being physically active in the afternoon (from 12 to 6 pm), as 161 (54.2 %) reported being active 2 to 3 times a week or more; in the evening (after 6 pm), this figure was 94 (31.6 %), and in the morning (before noon), 43 (14.5 %) reported being physically active. Eleven (3.7 %) students were completely inactive during the previous week. Figure 1 also shows that males and females reported a similar physical activity pattern during the week.

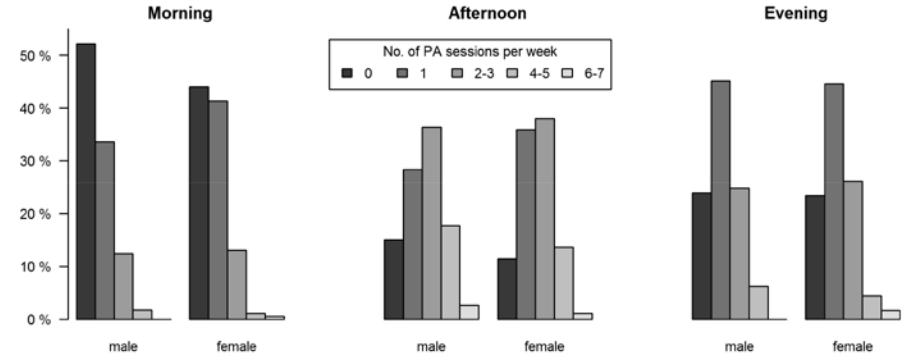

Figure 1. Weekly Frequency of Physical Activity of Students by Gender and Time of Day.

For vigorous exercise of at least 15 minutes, 79 (26.6 %) students reported no engagement, and 82 (27.6 %) students exercised vigorously only once a week. For moderate exercise of at least 15 minutes, 106 (35.7 %) students reported exercising once a week, while 62 (20.9 %) reported never exercising at this intensity level. 78 (26.3%) students engaged in exercises requiring low effort once a week, while 94 (31.6 %) students reported no engagement (Figure 2). Based on the criteria set forth in the WHO's guidelines (WHO, 2004), 237 (79.8 %) students were inactive or insufficiently active because they were not physically active for at least 150 minutes of moderate-intensity, or at least 75 minutes of vigorous-intensity, exercise throughout the week. Among these students, approximately half expressed a lack of free time and being overburdened with study as the reasons for their inactivity.

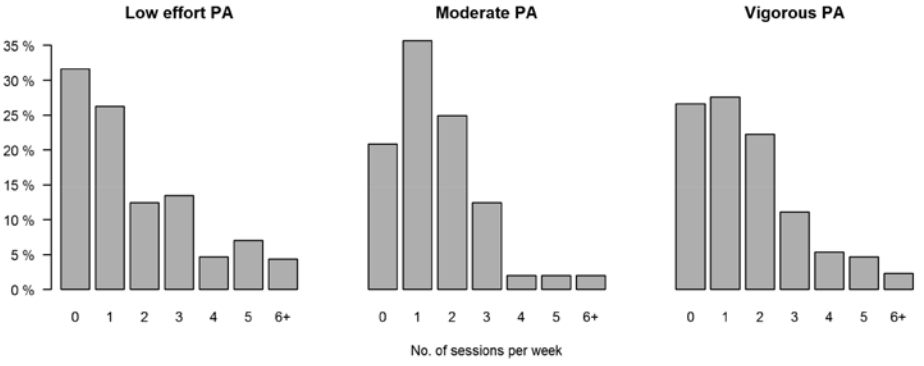

Figure 2. Frequency of Weekly Physical Activity (PA) Lasting Longer Than 15 Minutes.

The anthropometric data results in Table 1 show that male students were higher, heavier and had a higher body mass index. Males also had larger circumferences and lower skinfolds with the exception of the abdominal skinfold. There were also no differences in age between the groups.

Table 1. Anthropometric data arranged by gender of students.

	Males n=114		Females n=183		p-value*
	mean	SD	mean	SD	
Age (years)	20.4	0.7	20.5	0.7	ns
Body height (cm)	180.7	6.7	166.2	5.9	<0.001
Body weight (kg)	80.0	10.5	64.0	12.3	<0.001
Body mass index (kg/m2)	24.5	3.0	23.1	4.3	<0.001
Upper arm circumference (mm)	305.1	27.7	272.8	34.5	<0.001
Thigh circumference (mm)	576.1	44.8	558.9	60.5	0.006
Abdominal circumference (mm)	871.7	83.7	824.5	119.4	<0.001
Upper arm skinfold (mm)	10.5	4.9	17.0	8.0	<0.001#
Back skinfold (mm)	13.9	5.8	16.3	8.9	0.006#
Thigh skinfold (mm)	18.0	9.0	24.3	8.7	<0.001#
Abdominal skinfold (mm)	18.7	8.5	19.2	8.4	ns#
Suprailiac skinfold (mm)	17.4	8.2	20.4	7.9	0.002#

* independent samples t-test; # Mann-Whitney U test; ns = not significant

The results in Table 2 show that males performed statistically significantly better than females in most of the twelve physical fitness tests, except in three flexibility tests (Standing forward bend and reach, Sit and reach, Shoulder rotation), where female students performed better than males and in Flamingo balance test where the difference is not significant.

Table 2. Physical fitness test results arranged by gender.

	Males n=114		Females n=183		p-value*
	m	s	m	s	
Plate tapping 20« (count)	48.9	4.9	46.2	4.7	<0.001
Polygon backwards (seconds)	9.0	1.6	11.9	2.2	<0.001
Wall toss test (count)	22.9	4.9	15.9	4.7	<0.001
Standing forward bend and reach (cm)	46.6	7.8	49.7	7.3	0.001
Sit and reach (cm)	22.6	7.9	26.6	7.3	<0.001
Shoulder rotation (cm)	109.4	15.5	88.5	16.7	<0.001
Standing long jump (cm)	225.9	24.1	161.8	22.5	<0.001
Sit-ups 60" (count)	49.8	9.2	41.1	9.1	<0.001
Flexed arm hang test (seconds)	24.6	17.0	11.5	13.6	<0.001#
Flamingo balance test (count)	9.3	5.0	9.7	4.7	ns #
20-m sprint (seconds)	3.2	0.2	4.1	0.4	<0.001
20-m shuttle run (VO2 max, ml/kg/min)	38.2	6.4	27.4	1.4	<0.001

M = mean; SD = standard deviation; * independent samples t-test; # Mann-Whitney U test; ns = not significant

To find out how physical activity correlates with physical fitness, we analyzed three different parameters describing the extent of physical activity: a) weekly duration of physical activity; b) the weekly frequency of vigorous exercise lasting at least 15 minutes and c) weekly frequency of moderate exercise lasting at least 15 minutes. As the significant differences between males and females in physical fitness were found, we decided to analyze this relation separately, by gender. The results in Table 3 provided several significant relationships between the duration and intensity of physical activity and fitness with primarily weak correlation coefficients.

Table 3. Correlation between Physical Activity and Physical Fitness Test Results, Arranged by Gender.

	weekly duration of physical activity in hours		weekly frequency of vigorous exercise lasting at least 15 min		weekly frequency of moderate exercise lasting at least 15 min	
	Males n=114 r**	Females n=183 r**	Males n=114 r**	Females n=183 r**	Males n=114 r**	Females n=183 r**
Plate tapping	0.20#	0.11	0.26*	0.13	-0.12	-0.03
Polygon backwards	-0.14	-0.15#	-0.19#	-0.18#	0.08	0.04
Wall toss test	0.36*	0.17#	0.28*	0.12	0.18	-0.09
Standing forward bend and reach	0.11	0.15#	0.02	0.14	0.00	0.04
Sit and reach	0.13	0.13	-0.04	0.04	0.11	0.06
Shoulder rotation	-0.03	0.00	0.00	-0.10	0.13	-0.10
Standing long jump	0.21#	0.14	0.26*	0.19*	-0.03	-0.01
Pull-up 60”	0.24*	0.17#	0.32*	0.21*	-0.05	0.11
Flexed arm hang test	0.25*	0.30*	0.25*	0.23*	0.11	0.21*
Flamingo balance test	-0.20#	-0.10	-0.14	-0.19*	0.05	0.02
20-m sprint	-0.06	-0.22*	-0.14	-0.22*	0.02	-0.08
20-m shuttle run	0.29*	0.23*	0.37*	0.28*	-0.01	0.00

r** = Spearman’s correlation coefficient; * = $p < 0.001$; # = $p < 0.05$

The influence of physical activity on academic success was analyzed by binary logistic regression (Table 4). The majority of students were academically successful and regularly admitted to the second year of study (86.5n%). Two or three hours of weekly physical activity had a positive influence on regular admission to the second year of study (OR = 3.37, 95 %, CI = 1.18–9.62, $P = 0.024$ and OR = 4.37, 95 % CI = 1.44–13.24, $P = 0.009$, respectively). Neither vigorous physical activity nor sports club membership had any influence on academic success (OR = 0.55, 95 % CI = 0.21–1.43, $P = 0.220$ and OR = 0.81, 95 % CI = 0.30–2.18, $P = 0.674$, respectively). Regarding the anthropome-

tric data, being overweight (as indicated by body mass index) also had no influence on academic success (OR = 0.72, 95 % CI = 0.31–1.69, *P* = 0.452).

Table 4. Binary logistic regression for the prediction of academic success.

	Regular admission to the 2nd year of study		**OR (95% CI)**	**p-value**
	No n=40 (%)	**Yes n=257 (%)**		
Weekly PA				
1 hour or less	11 (27.5)	30 (11.7)	1.00 (reference)	
2 hours	8 (20.0)	64 (24.9)	3.37 (1.18 – 9.62)	0.024
3 hours	7 (17.5)	75 (29.2)	4.37 (1.44 – 13.24)	0.009
4 hours	5 (12.5)	37 (14.4)	3.54 (0.99 – 12.59)	0.051
5 hours or more	9 (22.5)	51 (19.8)	3.26 (0.86 – 12.45)	0.083
Vigorous PA				
2x weekly or less	28 (70.0)	199 (77.4)	1.00 (reference)	
3x weekly or more	12 (30.0)	58 (22.6)	0.55 (0.21 – 1.43)	0.220
Moderate PA				
2x weekly or less	34 (85.0)	208 (80.9)	1.00 (reference)	
3x weekly or more	6 (15.0)	49 (19.1)	1.09 (0.38 – 3.11)	0.875
Low effort PA				
2x weekly or less	31 (77.5)	179 (69.6)	1.00 (reference)	
3x weekly or more	9 (22.5)	78 (30.4)	1.18 (0.51 – 2.76)	0.700
Sports club membership				
No	30 (75.0)	206 (80.2)	1.00 (reference)	
Yes	10 (25.0)	51 (19.8)	0.81 (0.30 – 2.18)	0.674
Body mass index				
<25 (normal)	27 (67.5)	187 (72.8)	1.00 (reference)	
≥ 25 (overweight)	9 (22.5)	51 (19.8)	0.72 (0.31 – 1.69)	0.452
≥ 30 (obese)	4 (10.0)	19 (7.4)	0.56 (0.17 – 1.88)	0.349
Gender				
Male	16 (40.0)	98 (38.1)	1.00 (reference)	
Female	24 (60.0)	159 (61.9)	0.94 (0.43 – 2.03)	0.868

OR = odds ratio, 95%CI = 95% confidence interval, PA = physical activity

DISCUSSION

International studies have shown that the percentage of physically inactive students varies from country to country: 23 % in Western Europe and the U.S., 30 % in Central and Eastern Europe, 39 % in Mediterranean countries, 42 % in the countries of the Asia-Pacific region and 44 % in developing countries (Haase, Steptoe, Sallis & Wardle, 2004). Guthold published data on levels of physical inactivity in 51 countries, most of which were low or middle income, and observed several trends (Guthold, Ono, Strong, Chatterji, & Morabia, 2008). Globally, with the exception of several Eastern European countries, women were more likely to be physically inactive than men. Few studies have explored the reasons for decreasing levels of physical activity in developing countries. Ng et al. (2009) estimate that between 1991 and 2006, average weekly physical activity fell by 32 per cent. Globally, around 23 % of adults aged 18 and over were not active enough in 2010 (men 20 % and women 27 %). In high-income countries, 26 % of men and 35 % of women were insufficiently physically active, as compared to 12 % of men and 24 % of women in low-income countries (World Health Organization, 2016).

The results of our study showed a more positive picture as only 7.4 % of students reported not being involved in vigorous or moderate exercise; however, 26.6 % of students reported not performing any vigorous exercise. The results of our study on the physical activity of students may therefore be considered similar to previous studies. With respect to the WHO recommendations (World Health Organization, 2004), with the time component of adequate physical activity included (150 minutes of moderate--intensity, or at least 75 minutes of vigorous-intensity throughout the week), our results are worse, showing that only 20.2 % of students reported adequate physical activity. For example, this percentage was similar to a national survey conducted by Caspersen, Fereira, and Curran (2000), who found that only 25 % of Americans reach the recommended level of physical activity. Regarding organized physical activity, our study showed that only 20.5 % of the students were active in a sports club. The percentage of students active in sports clubs is close to the figure in Croatia (23 %) (Andrijašević, Paušić, Bavčević & Ciliga, 2005), although another study has suggested that only 16 % of Slovene students are actually active in sports clubs (Golja & Robič, 2014).

In Sweden, however, it was reported that the percentage of young people engaged in sport clubs is increasing, as 66 % of boys and 53 % of girls were active in them (Westerståhl, Barnekow-Berkvist, Hedberg & Jansson, 2003), a percentage that is considerably higher than the levels in Slovenia or Croatia. Our results showed that students were under-active, considering that a healthy adult requires a minimum physical activity time of at least 150 minutes of moderate exercise per week (such as fast walking, cycling on flat terrain, or even mowing the lawn) or 75 minutes of vigorous exercise (running, swimming, rough terrain biking, playing basketball or tennis) (Janssen, 2001), where only approximately 20.2 % of students reported sufficiently frequent engagement.

Since the results of the physical fitness tests indicated significant differences between males and females, we decided to calculate the correlation between physical activity and fitness tests results by gender. The results show that in this gender comparison,

there is on average a smaller share of women who take part in no physical activity, but a higher percentage who take part in physical activity once or two to three times per week. The study demonstrates that male students outperformed their female counterparts in almost all motor tests except the flamingo, which measures balance, where no significant difference was found and in flexibility, where female students performed better than male.

The second purpose of the study was to explore the relationship between the reported extent of weekly physical activity and physical fitness. In most cases, especially in overall weekly duration of physical activity and weekly frequency of vigorous exercise lasting at least 15 minutes, physical activity is positively correlated to physical fitness, however most correlation coefficients were low and, in some cases, also not statistically significant. Even weaker correlation was found between weekly frequency of moderate exercise lasting at least 15 minutes and physical fitness. The only coefficients exceeding 0.3 were those between overall duration of physical activity and the frequency of vigorous exercise with the wall toss test, pull-up 60" and 20-m shuttle run among male students. Similarly, Renfrow et al. (2011) found that males who played more sports achieved significantly better FitnessGram overall scores. In a longitudinal study, Aires et al. (2010) found that an increased physical activity index contributed to improved physical fitness. Associations between physical activity and physical fitness tests, as documented in available studies such as Martinez-Vizcaino & Sanchez-Lopez, (2008), Fang et al. (2017) show the positive effects of increased physical activity for improved health-related physical fitness in children and young people (Martínez-Vizcaíno & Sánchez-López, 2008; Malina, Bouchard & Bar-Or, 2004).

Our last research aim was to explore whether the extent of physical activity influences academic success, which was defined as regular admission from the first to the second year of study. In previous researches, physical activity has not clearly been associated with academic performance (Daley & Ryan, 2000; Sallis et al., 1999; Tremblay et al., 2000). Our results provided some evidence that higher duration of physical activity may positively influence academic performance, which was similar to Coe et al. (2006), Kim et al. (2003) California Department of Education (2001), Sibley & Eitner (2003), Castelli, Hillman, Buck & Erwin (2007) and Trost (2016). On the other hand, our results regarding comprehensive vigorous physical activity or sports club membership provided no proof of their positive influence on academic success. This might suggest that two to three hour weekly recreational physical activity is positive for one's academic success, while sporting physical activity is probably too exhausting and time- consuming.

Study Limitations

Measuring weekly physical activity among the population is difficult because its duration, intensity, frequency, and type of exercise performed are seldom recorded. Physical activity is usually performed with less consistency, more often in some weeks, in others less, sometimes physical activity is performed on weekends, sometimes

during the week, etc. Therefore, participants face difficulties in reliability and reporting every detail of their weekly physical activity. To reduce bias, we gathered data about physical activity with several measures: weekly duration in hours, frequency by intensity of exercise (vigorous and moderate), larger sample, the greater number of faculties and different level of exercise (low effort PA, moderate PA, vigorous PA).

CONCLUSIONS

This study indicates that the duration of physical activity has only a limited influence on the academic performance of undergraduate students. Two to three hour weekly recreational physical activity proved beneficial, while comprehensive vigorous exercise and sports club participation did not. According to the literature, we expected stronger correlations between the reported extent of weekly physical activity and fitness test performance. Similarly, we did not expect such negative / bad results about the extent of physical activity among students, as they in general reported physical activity below international recommendations. In Slovenia, the number of physically active students would most certainly increase if each faculty had adequate sports facilities and equipment which students could use in their leisure time free of charge.

Both society in general and individuals can take action to increase physical activity. In 2013, WHO Member States agreed to a target of reducing insufficient physical activity by 10 % by 2025 and included strategies to achieve this goal in the „Global Action Plan for the Prevention and Control of Non-communicable Diseases 2013-2020“. Slovenia should also adhere to this action plan.

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ETHICAL APPROVAL

Written informed consent was obtained from all tested students

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EFFECTS OF 8-WEEK ELECTRICAL MUSCLE STIMULATION ON THE MUSCLE CONTRACTILE PROPERTIES IN ADOLESCENT GIRLS

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ABSTRACT

The study aimed to determine the effect of 8-week unilateral electrical muscle stimulation (EMS) training of leg muscles: vastus lateralis, vastus medialis and biceps femoris with the same number of muscle contractions in comparison to controls. Contractile properties were monitored by measuring the maximal voluntary isometric contraction (MVC) and the rate of force development in first 50 ms (RFD_{50}) of knee extensors and flexors and tensiomyography of stimulated muscles. In addition, we also investigated the retained effect after 8 weeks without EMS training. Nineteen healthy young female athletes aged 15 to 18 years (average 16.4 ± .9 years) were randomly divided in a control group (CG; N=8) and an experimental group (EG; N=11). CG performed maximal unilateral voluntary contractions while the EG performed also EMS training of the same leg by stimulating both vasti muscles and biceps femoris. There were no changes in CG after 8 weeks of maximal unilateral voluntary training; however, EG improved MVC in knee extensors (12.6 %; P = .085) and RFD_{50} (142.1 %; P = .049) where RFD_{50} retained increased also 8 weeks after EMS training (73 %; P = .090). Tensiomyography revealed decreased amplitude (13.2 %; P = .011) only in EG, representing higher muscle tone after 8 weeks of EMS in comparison to CG. Our findings indicate that EMS training has a positive effect on muscle contractile properties in young female athletes even after comparing to matched controls by the number of contractions.

Keywords: *EMS, muscle strength, tensiomiography, rate of force development.*

VPLIV 8-TEDENSKE ELEKTRO MIŠIČNE STIMULACIJE NA KONTRAKTILNE LASTNOSTI MIŠIC MLADIH ŠPORTNIC

IZVLEČEK

Cilj študije je bil raziskati vpliv 8 – tedenskega unilateralnega EMS treninga na lastnosti m. vastus medialis, m. vastus lateralis in m. biceps femoris v primerjavi s kontrolno skupino z enakim številom mišičnih kontrakcij. Kontraktilne lastnosti mišic smo spremljali z merjenjem največje izometrične mišične silovitosti (MVC) in hitrosti prirastka sile v prvih 50 ms (RFD_{50}) mišic iztegovalk in upogibalk kolena ter tenziomiografskega odziva mišic. Poleg začetnih meritev in meritev po 8 tednih nas je zanimal še zadržan učinek po 8 tednih brez EMS. Devetnajst zdravih mladih športnic, starih od 15 do 18 let (v povprečju 16.4 ± .9 let), smo naključno razdelili v kontrolno (CG; N = 8) in eksperimentalno skupino (EG; N = 11). CG je izvajala enonožne maksimalne hotene kontrakcije, medtem, ko je EG izvajala tudi trening EMS iste noge s stimulacijo srednje in stranske mogočne mišice ter dvoglave stegenske mišice. Po 8 tednih vadbe nismo našli razlik v CG, medtem, ko sta se v EG povečali MVC iztegovalk kolena (12.6%; P =.085) in RFD_{50} iztegovalk kolena (142.1%; P =.049), ki je ostala povečana tudi 8 tednov po zaključku EMS treninga (73%, P =.090). Tenziomiografija je pokazala na zmanjšano amplitudo le pri EG (13.2%; P =.011), ki je po 8 tednih EMS v primerjavi s CG predstavljala višji mišični tonus. Slednje ugotovitve kažejo na to, da EMS pozitivno vpliva na kontraktilne lastnosti mišic mladih športnic, tudi po primerjavi s kontrolno skupino z istim številom kontrakcij.

Ključne besede: *EMS, mišična silovitost, hitrost prirastka sile, tenziomiografija.*

INTRODUCTION

Electrical muscle stimulation (EMS) includes involuntary muscle contractions as a response to the electrical currents produced by the electrical device and applied through electrodes on muscles (Seyri & Maffiuletti, 2011; Đokić & Međedović, 2013). The stimulation impulse or pulses could be applied directly on muscles or peripheral nerve (Benito-Martinez, Martinez-Amat, Lara-Sanchez, Berdejo-del-fresno, & Martinez-Lopez, 2013; Enoka, 1988). Initially, EMS was used only for therapies; however, in the last two decades, there was an increment in the EMS usage for conditioning purposes (Pichon, Martin, & Cometti,1995; Malatesta, Cattaneo, Dugnani, & Maffiuletti, 2003; Brocherie, Babault, Cometti, Maffiuletti, & Chatard. 2005; Babault, Cometti, Pousson, & Chatard, 2007; Maffiuletti, et al., 2009; Deley, Cometti, Fatnassi, Paizis, & Babault, 2011; Benito-Martinez, Sanchez-Lara, Berdejo del Fresno, & Martinez-Lopez, 2011; Martinez–Lopez, Benito-Martinez, Hita-Contreras, Lara-Sanchez, & Martinez-Am-

at, 2012). Investigators reported positive improvements in isometric muscle strength (Maffiuletti, Pensini, & Martin, 2002; Singer, 1986; Zhou, Oakman, & Davie, 2002; Sariyildiz, Rezvani, & Karacan, 2011), isokinetic strength (Deley, et al., 2011; Lategan, Crafford, Suliman, & Govender, 2014), vertical jumping height (Malatesta, et al., 2003; Babault, et al., 2007; Martinez-Lopez, Benito-Martinez, Hita-Contreras, Lara-Sanchez, & Martinez-Amat, 2012), skating and sprinting speed performance (Brocherie, et al., 2005; Benito - Martinez, et al., 2011) and motor tests (Deley, et. al., 2011; Benito - Martinez, et. al., 2011). Most of the studies were carried out on stimulating muscle quadriceps femoris (Maffiuletti, et al., 2000; Malatesta, et al., 2003; Gondin, Guette, & Martin, 2005; Babault, et al., 2007), muscle triceps surae (Babault, et al., 2007; Malatesta, et al., 2003), while just two studies performed EMS on muscle biceps femoris (BF) (Lategan, et. al., 2014; Marqueste, et. al, 2010).

Only five studies examined the effect of EMS on adolescent athletes (Martinez–Lopez, et al., 2012; Benito–Martinez, et al., 2013; Benito-Martinez, et al., 2011; Malatesta, et al., 2003; Deley, et al., 2011) and just one was done on girls only (Deley, et.al., 2011). Among them, Martinez – Lopez, et. al. (2012) reported that the combination of 8 weeks of plyometric and EMS training improve squat jump height for 28 %, countermovement jump for 13.7 % and drop jump height for 4.1 %. Benito–Martinez, et. al. (2013) found that the combination of 8-week EMS and plyometric training improved 30-meters sprint time for 6.8 % and the triple jump distance for 5.2 % but only in a group that practiced plyometric training before the EMS was applied. Interestingly, the study of Benito–Martinez, et. al. (2011) showed that countermovement vertical jump height improved for 13.5 % in a group that applied EMS before they practiced. Effects of EMS were found also after shorter exposures, where Malatesta, et. al. (2003) observed improvements in jumping mechanical power during 15 seconds of consecutive jumps (3.8 %) after only 4 weeks of EMS training. Interestingly, after ten days of follow-up the improvements in squat jump (6.5 %), counter movement jump height (5.4 %), 15-second consecutive jump height (5.3 %) and jumping mechanical power (5.9 %) were still present.

Deley, et. al. (2011) were the only ones investigating EMS effects in adolescent girls (12.4 ± 1.2 years) and found that 6-week combined EMS and gymnastic training improved maximal voluntary torque at three different angular velocities already after 3 weeks (38.8 ± 29.0% at -60˚s^{-1}, 25.9 ± 28.0% at 60˚s^{-1}, 40.2 ± 22.0% at 240˚ s^{-1}) and interestingly not after 6 weeks. After 3 weeks of training, they found also improvements in squat jump height (20.9 ± 8.3 %), reactivity test (20.4 ± 26.2 %) and specific jump performance tests (14.9 ± 17.2 %). Squat jump height was also improved after 6 weeks of training while other tests were not. The improvements in counter movement jump height were present only after 6 weeks of training (10.1 ± 10.0 %). After 4 weeks of follow-up, only squat jump height remained improved. Obviously, there are discrepancies in data of the presented maximal voluntary tests that warrants more objective measures of muscle contractility improvements after EMS.

The most important physiological aspect which differs between EMS and voluntary contraction is recruitment of motor units. EMS recruit motor points randomly and non-

selective (Gregory & Bickel, 2005), while in voluntary contraction recruitment follows the Henneman size principle (Henneman, Somjen, & Carpenter, 1965). This indicates that the EMS can recruit more fast motor units and we would expect increase in overall skeletal muscle contraction velocity. Although skeletal muscle contraction velocity could not be determined by dynamometry, non-invasive tensiomyography (TMG) was developed to detect mechanical properties of the skeletal muscles where contraction time alone or pooled with delay time and half-relaxation time correlates with myosin heavy chain I proportion (Šimunič et al., 2011). TMG was previously used in adults in an 8-week plyometric study, where Zubac and Šimunič (2016) demonstrated shorter contraction time of 4 (out of 5) lower limb muscles and lower TMG response amplitude in all muscles. However, TMG was not used after EMS training study.

Therefore, the aim of our study was to determine the effect of 8-week EMS training of non-dominant leg on the TMG and MVC-derived contractile properties of vastus lateralis (VL), vastus medialis (VM) and BF muscle in young female athletes. In addition, we also investigated the retained effect after 8 weeks of follow-up.

METHODS

Participants

Twenty young female athletes (average age: 16.4 ± .9 years, Table 1) voluntarily decided to participate in the study. The girls have practiced regularly various sports such as artistic roller skating, athletics, handball, gymnastics, dancing, cheerleading and twirling for at least last 5 years. Their sport training was carried out 3 – 6 times per week, in average 5 times per week. Most of the girls competed at international level, nine of them also at European and World championships, other at national level. The study was presented to the parents and girls together with the purpose of the study and its intended course and the procedures that will be carried out in the framework of the research. The parents of the girls signed an informed-consent prior to the study. The study was approved by Institutional ethics board at Science and Research Centre Koper.

Study Design

The research lasted for almost five months and was consisted of three testings. After the familiarization in the first week, the initial testing (BDC) was carried out, followed by 8-week interventions in both groups. The second testing (END) was performed after the interventions. Furthermore, the third testing (FU) was carried out after 8 weeks of follow-up period. After the BDC, one girl was excluded from the study due to many diseases yielding 19 participants for data analysis. The girls were randomly divided into two groups: the control group (CG; N = 8) and the experimental group (EG; N = 11), see Table 1.

Table 1: Anthropometric data of our sample of participants.

	All	Control group	Experimental group	P
N	**19**	**8**	**11**	
Age / years	16.4 ± .9	16.1 ± .8	16.6 ± .9	.326
Body height / cm	163.7 ± 4.6	166.6 ± 2.3	161.6 ±4.8	.014*
Body mass / kg	57.9 ± 6.9	58.0 ± 6.3	57.4 ± 7.6	.735
Body mass index / m/kg²	21.6 ± 2.3	21.1 ± 2.2	22.0 ± 2.4	.427
Fat mass / %	25.5 ± 5.5	23.9 ± 5.4	26.6 ± 5.5	.313
Muscle mass / kg	19.0 ± 1.3	19.6 ± .8	18.6 ± 1.5	.116

* = significant differences between CG and EG at p <. 05.

Exercise intervention in CG

After BDC, the active CG performed 8 weeks of supervised physical exercise 3 times per week. The participants warmed up with 6 minutes of jogging and 4 minutes of whole-body stretching. After the warm up, participants performed one leg (non-dominant) hip raise when lying on the floor for exercising BF. The subjects were lying on the back, while non-dominant leg was in knee flexion at angle of about 30 degrees with heel placed on the floor. The dominant leg was suspended in the air. The upper legs were parallel in the width of the hips. The arms were crossed on the chest. Hip raise was performed until the line shoulder-hip-knee was aligned for 3 seconds. Then they lowered their hip to the original position in which they waited and relaxed for 17 s. The participants performed 36 repetitions, with the intention to equalize the number of the contractions with EG. The exercise progressiveness was achieved with lifting heel support and with additional loads placed on the hips. They started exercising with body weight and a foot on the ground. Then we increased the support of the heel for 35 cm. After that we added 2.5 kg, then 5 kg, followed by 7.5 kg and at the end 10 kg on the hips. Out of all CG, only two girls increased the loading up to 10 kg, others got up to 7.5 kg.

EMS Intervention in EG

The girls in EG conducted one EMS training session a week before the BDC for familiarization. After the BDC, they performed EMS training for 8 weeks, 3 times per week. The EMS session consisted of 13 minutes of isometric EMS of knee extensors

(vasti muscles at the same time) and 13 minutes of isometric EMS of knee flexors (BF). For EMS, we used two Cefar Rehab x2 electrical stimulators (CefarCompex, Scandinavia AB). Before the EMS, the participants warmed up with 6 minutes of jogging and 4 minutes of stretching the whole body. Then we placed 6 self-adhesive electrodes on subject's thighs. Four positive electrodes, one-wire, were in the size of 5 x 5 cm while two negative electrodes, two-wire, were in the size of 5 x 10 cm. All electrodes were from Dura-Stick plus, Cefar Compex, DJO brands. In the case of BF, the negative electrode was placed on the posterior side of the thigh just below the muscle gluteus maximus (GM) while the positive electrodes were placed as close as possible to the motor point of m. semimembranosus and BF. On the front side of the thigh, we positioned the positive electrodes as close as possible to the motor points of VL and VM or on their muscular belly. The negative electrode was placed on the femoral triangle or 1-3 cm below the inguinal ligament. During the stimulation of VL and VM, the participants were sitting on a machine for knee extension or on the chair. During the knee extension, the stimulated leg was fixed in isometric position. Among the EMS session of BF, the subjects were lying on the abdomen and had a non-dominant leg stretched out, again rested and fixed in isometric position. All the exercises were carried out isometrically. EMS parameters were: a biphasic electric impulse with a pulse length of 400 μs and a frequency of 100 Hz, 1s of rise up, 3 s of muscle contraction, 5 s of fall time and 17 s of pause with 8 Hz pulse currents. During the EMS session, each subject performed 36 repetitions of knee extension and 36 repetitions of knee flexion. The intensity level of the EMS was for each session the highest, according to the pain threshold and as a maximum tolerated level of each individual.

Measurements

Firstly, we measured the participants' body height and weight with standard tools from which we calculated body mass index. For determination of body composition, we performed bioelectric impedance analysis (Maltron Bioscan 916s, UK). Before measurement, the participants had to lay down on the measuring table for 30 minutes and then we placed two self-adhesive electrodes on the palm and two on the foot. We collected fat mass (FM, %) and muscle mass (MM, kg) data for further analysis.

Tensiomyography

We measured maximal TMG response in all observed muscles. Firstly, we examined VL and VM where the participants were lying supine with knee flexed at 30 degrees (0 degrees represents fully extended joint. Afterwards, we measured BF where the participants were prone. For each muscle two surface self-adhesive electrodes were placed on the measured muscle at a distance of 5 cm proximally and distally from the sensor (Digital–optical comparator, TMG-BMC Ltd, Slovenia). The electrodes were

connected to an electric stimulator (TMG-BMC Ltd., Slovenia). The sensor was positioned perpendicularly to the tangential plane of the measuring point. Measuring point was determined by a skilled expert, where the response reaches largest response. The stimulation impulse (monophasic rectangular electrical stimulus of 1 millisecond) was gradually increased from threshold to maximal amplitude. In each muscle we recorded two maximal twitch responses. From both, contraction time (Tc) and maximal amplitude (Dm) were extracted. Tc was defined as the time when muscle contracted from 10 % Dm to 90 % Dm. An average of was taken for further analysis.

Isometric Dynamometry

We measured unilateral maximal voluntary isometric contraction (MVC) and rate of force development (RFD) of knee flexors and extensors. The order of MVC and RFD measurement was as follows: MVC of right knee extensors, right knee flexors, left knee extensors and left knee flexors. Firstly, we placed the participants sited in knee dynamometer (S2P, Science to Practice, Ltd., Slovenia). The participant's femur epicondyle was in line with the dynamometer axis of rotation. The participants were firmly attached through the chest and hip with a belt. Distal part of the tibia was attached firmly to strength gauge. For measuring MVC and RFD, the knee angle was set at 60° and 30° for knee extensors and flexors, respectively. When measuring knee flexor, we added another belt to fix the upper leg. Prior to each measurement, a special warming-up was carried out. Warming-up included two submaximal isometric contractions at 50 % and 70 % of MVC and one at 100% MVC. The pause between repetitions was 60 s. Each isometric contraction lasted 5 s, so that participants could escalate force in 2 s and retain force at 50 %, 70 % or 100 % MVC for 3 s. Afterwards, we performed the main measurements. Even in the main measurements, the contraction time lasted 5 s as in the case of warming up ("1,2,3, hold, hold, hold, release": total 5 s). The pause between the individual measurements was 60 s. After the MVC measurements, we continued with RFD measurements in the same order. In this measurement, special warming included just one measurement in which the participants on the sign "now" had to develop greatest maximal force in the shortest possible time and hold the force for 2 – 3 s and then release the muscle. The main measurement was followed by three measurements of maximal RFD in each position. The procedure was the same as in the warming up. The pause between individual measurements was 60 s. The signals were captured and stored using a dynamometric ARS program "Analysis and Reporting Software for Dynamometers" (S2P, Science to Practice, Ltd., Slovenia). We took maximal MVC amplitude (Nm) and RFD_{50} in first 50 ms (Nm/s) for further analysis.

Statistical Analysis

Mean values and standard deviations (±SD) were calculated for all dependant variables. All variables pass normality and homogeneity tests (Shapiro-Wilk, Q-Q plot, visual inspection, Leven test). A repeated measures general linear model was used to assess the interaction between EG and CG with time in each dependent variable. If significant interactions were confirmed, we performed One-way ANOVA using Bonferroni correction to identify specific effects. When reporting specific effect, we presented partial eta squared for presenting effect size. The level of significance was established at $P < .10$ for all decisions. Statistical analyses were performed using Statistical Product and Service Solutions (IBM SPSS Statistics 22, USA).

RESULTS

The participants have done 22 to 24 trainings (average 23.4± .7 trainings), yielding 97.5 % adherence to the training programme. There were no differences between the two groups at the beginning of the study in the dependant variables except participants' body height. We did not observe and report any discomfort or injuries during and after the training program. The study protocol was carried out with no modifications.

In Table 2 we reported time effects in MVC of knee extensors ($P=.019$; $\eta^2=.213$) and knee flexors ($P=.019$; $\eta^2=.209$) as well as in RFD_{50} of knee extensors ($P=.023$; $\eta^2=.200$). Time x Group interactions were found in MVC ($P=.044$; $\eta^2=.172$) and RFD_{50} ($P=.046$; $\eta^2=.166$) of knee extensors. Post hoc revealed increases in MVC of knee extensors in EG but not in CG at END ($P = .085$). Similarly, RFD_{50} of knee extensors increased in EG, not in CG, at END ($P = .049$) and remained increased at FU ($P = .090$).

Table 2: Results of maximal voluntary isometric contraction (MVC) and rate of force development in first 50 milliseconds (RFD_{50}) of knee flexors and knee extensors of non-dominant leg.

Variables	Experimental group			Control group				
	BDC	END	FU	BDC	END	FU	P_{Time} (η^2)	$P_{Time\ x\ Group}$ (η^2)
MVC – knee extensors / Nm	161.6±37.0	182.0±35.1*	172.5±31.2	151.4±21.6	152.7±33.6	152.3±31.5	.019# (.21)	.044# (.17)
MVC – knee flexors / Nm	81.4±13.8	89.2±17.8	89.1±13.0	72.6±11.1	81.3±13.4	79.0±14.5	.019# (.21)	.930
RFD_{50} – knee extensors (Nm/s)	61.0±38.5	147.7±49.4#	105.5±71.7*	85.7±59.7	91.9±65.4	58.0±21.9	.023# (.20)	.046# (.17)
RFD_{50} – knee flexors (Nm/s)	70.3±30.5	106.7±62.3	63.3±33.2	62.6±37.4	74.3±49.5	76.8±42.7	.116	.179

BDC = baseline assessment; END = assessment after 8-week intervention; FU = 8-week follow-up assessment; * and # = significant differences from BDC at $p<0.1$ and $p<.05$, respectively.

Table 3 reports the results obtained with tensiomyography, namely contraction time and maximal amplitude of biceps femoris and vasti muscles. We found Time x Group interaction effect only in VM Dm (P=.040; η^2=.185) and post-hoc analysis of individual relative changes revealed lower Dm in EG for 13.2% (P=.011) at END.

Table 3: Tensiomyography results of biceps femoris (BF), vastus lateralis (VL) and vastus medialis (VM) contraction time (Tc) and maximal amplitude (Dm) in non-dominant leg.

Variables		Experimental group			Control group				
		BDC	END	FU	BDC	END	FU	P_{Time} (η^2)	$P_{Time\ x\ Group}$ (η^2)
BF	Tc	38.5±8.3	42.8±11.4	42.5±8.5	36.8±10.2	39.1±9.1	36.3±4.8	.257	.469
	Dm	6.7±1.7	7.0±1.9	7.6±2.2	7.5±2.0	8.8±1.8	8.6±1.6	.062	.426
VL	Tc	20.5±2.4	20.9±2.2	21.5±2.1	20.8±1.7	21.3±2.2	21.4±1.6	.115	.718
	Dm	5.6±1.7	4.9±1.2	5.5±1.1	5.9±2.0	5.7±1.5	6.3±1.6	.087	.690
VM	Tc	21.9±2.4	20.3±2.0	21.2±1.9	20.8±1.2	20.3±2.0	21.0±2.0	.729	.299
	Dm	7.6±1.4	6.6±1.1*	7.1±1.3	6.7±1.8	6.9±1.5	7.4±1.7	.121	.040* (.18)

BDC = baseline assessment; END = assessment after 8-week intervention; FU = 8-week follow-up assessment;
* = significant differences from BDC at $p < .05$.

DISCUSSION

We found increased MVC strength (12.6 %) and RFD_{50} (142.1 %) of knee extensors after 8 week of EMS training in EG but not in an active CG. Furthermore, we noticed increased RFD_{50} of knee extensors also after 8-week follow-up (73 %). Increased isometric strength was also determined in previous studies; however, increments were higher due to passive CG and even shorter EMS training periods. Selkowitz (1985) reported 44 % increased MVC strength in quadriceps after only 4 weeks of EMS, Stefanovska and Vodovnik (1985) reported 13.2 to 25.3 % increased MVC strength of knee extensors by 25.3 % after 3 weeks of EMS training, Lai, De Domenico, and Strauss, (1988) reported 48.5 % and 24.2 % increments in MVC strength of quadriceps after 3 weeks of high intensity and low intensity EMS training, respectively, with decreased but sustained (24.8 and 12.8 %, respectively) effects after the 3-week follow-up period. The study of Maffiuletti, Dugnani, Folz, Di Pierno, and Mauro, (2002) performed in athletes (volleyball players) reported comparable MVC strength gains after 4 weeks of combination of plyometric and EMS training (28.5 %). However, Herrero, Izquierdo, Maffiuletti, and Garcia-Lopez (2005) demonstrated in athletes that the combination of 4-week plyometric and EMS training demonstrated superior effects on quadriceps MVC strength (16.3 %) vs. EMS training (9.1 %) and that is comparable to the findings of our study. Similar results were demonstrated also by Billot, Martin, Paizis, Cometti, and Babault, (2010) that showed a 16.3 % increase in MVC strength of quadriceps in footballers after 3 weeks of EMS training. Our study implemented a longer EMS training period, being 8 weeks, in young female athletes and with an active control group making direct comparison to other studies impossible. Gains of 12.6 % from baseline and 19.2 % from active CG at the end of the training period are somehow lower that those reported by others. Surely this must be attributed to the population studied and an active CG that was equalised to EG by the number of muscle contractions.

The mechanisms of MVC improvements after EMS were found on nervous and muscle levels. Gondin et al. (2005) reported increased muscular activation, anatomical cross-sectional area and pennation angle after 8-week EMS. In addition, they also reported nerve adaptations to occur within the first four weeks of EMS, while changes in muscle cross sectional area and pennation angle after 8-weeks of EMS. It seems that changes at the muscle level (e.g. hypertrophy, architecture) occur after 5 weeks of intense EMS training (Herrero et al., 2005; Maffiuletti, Dugnani, Folz, Di Pierno, & Mauro, 2002). Therefore, the MVC gains obtained after EMS training could be attributed to muscular and neural adaptations, at least for monoarticular muscles (Gondin et al., 2005).

Based on the results of TMG, an indirect measure of myosin heavy chain composition (Šimunič et al., 2011) and atrophy (Pišot et al., 2008), we could conclude that there were no changes found in muscle composition (Tc remained unaltered) but there was smaller Dm found in VM without sustained effects at the follow-up. Since increases of Dm were already correlated to muscle atrophy after 35 days of bed rest (Pišot et al., 2008; Šimunič et al., 2008), the opposite, decreases of Dm were found after high-inten-

sity plyometric exercise (Zubac & Šimunič, 2016). Both aforementioned bed rest studies (Pišot et al., 2008; Šimunič et al., 2008) also investigated hypertrophy after bed rest, and during the recovery period that followed bed rest when Dm returned to baseline values. Decreases in Dm after plyometric training were paralleled to increases of muscle stiffness (Spurrs, Murphy, & Watsford, 2003), which has a marginal effect on the capacity of skeletal muscle to effectively utilize elastic energy (Avela & Komi, 1998) and movement efficacy (Pellegrino, Ruby, & Dumke, 2016). There are many possible mechanisms that could affect Dm, a measure of muscle belly stiffness. Presumably, alterations in muscle stiffness could be modulated via changes in the visco-elastic properties of intramuscular and tendon connective tissue (Pišot et al., 2008). Alterations of pennation angle following bed rest, training, etc. might impact Dm either way, depending on the new initial sarcomere length, due to an increase in the fascicle length and / or more direct muscle fibre thickening and oscillation transfer in the transversal plane (to the TMG sensor) of muscle contraction. On the other hand, Fouré, Nordez, McNair, and Cornu (2011) demonstrated no change in muscle architecture in response to 14 weeks of plyometric training; however, they did note an increase in the passive series elastic component and a decrease in the active series elastic component. A decrease in the active SEC (mainly in the intrinsic mechanical properties of the muscle fibres) could occur due to a fibre-type transition phenomenon (Potteiger et al., 1999); however, this was not found in our study. Therefore, the Dm decrease must be linked to the passive series elastic component, which increases after high-intensity training (Burgess, Connick, Graham-Smith, & Pearson, 2007; Fouré et al., 2011) and as well after the EMS (Da-Haeng, Jae-Keun, & Joon-Hee, 2015).

Only two studies reported the RFD after EMS (Schmithusen, 2008; Speicher & Kleinoder, 2009). After 4 weeks of EMS isometric training for the upper part of the body, Schmithusen (2008) reported 58 % increase of RFD and a 20 % increase in the force impulse (< 200 ms). Speicher and Kleinoder (2009), reported a similar, 16 % increase of force impulse (<200 ms) after 4 weeks of EMS in lower part of the body, without finding changes in the RFD. Our study was in line with findings of Schmithusen (2008) and we demonstrated increased RFD (<50 ms) for 60.7 % with sustained effects after the follow-up period. Shorter time interval of RFD makes these three studies difficult to compare. Most likely, the order of motor unit recruitment, that occurs after EMS training (Maffiuletti, 2010; Seyri & Maffiuletti, 2011; Jubeau, Gondin, Sartorio, & Maffiuletti, 2007), plays an important role in increasing the RFD. During EMS, training motor units are recruited non-selectively and randomly in terms of size, and not according to Henneman's size principle in voluntary contractions. Jubeau et al. (2007) and Maffiuletti (2010) have demonstrated that during electrically elicited contractions the contraction time is stable when muscle is recruited between 20 and 80 % of contraction intensity. In addition, during EMS training / contractions, fast motor units are easier and more activated compared to voluntary training / contractions at submaximal intensity (Billot et al., 2010). Therefore, we suggest that EMS training caused alterations in recruitment order during short maximal contractions (RFD_{50}) that is reflected in higher RFD_{50} due to activation of fast motor units.

CONCLUSION

The study confirmed the effectiveness of EMS on skeletal muscle contractile properties in young female athletes. After controlling with an active control group we have demonstrated higher MVC and RFD_{50} of knee extensors, with higher muscle tone in VM. While the effects returned to baseline values in $RFD_{50,}$ remained significant also after eight weeks of follow-up.

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PSYCHOLOGICAL BENEFITS OF EXERCISE AND PHYSICAL ACTIVITY IN OLDER ADULTS

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ABSTRACT

While regular physical activity has been shown to positively impact health and physical functioning across all age groups an active lifestyle may in particular have beneficial effects in advanced age. The objective of this article is to provide a brief overview of a contemporary research on the benefits of physical activity for psychological health and quality of life in the elderly. Older adults are more vulnerable than other age groups regarding mental health problems, such as depression and anxiety. Many cross-sectional and experimental studies discussed in the article confirm the importance of a physically active lifestyle for preventing or reducing mental health problems and improving the quality of life among elderly people.

Keywords: *mental health, physical activity, quality of life, late adulthood.*

POZITIVNI PSIHOLOŠKI UČINKI GIBALNE/ŠPORTNE AKTIVNOSTI PRI STAREJŠIH ODRASLIH

IZVLEČEK

Redna gibalna/športna aktivnost pozitivno vpliva na gibalne zmogljivosti in zdravje posameznikov v vseh starostnih skupinah, predvsem pa ima aktivni življenjski slog lahko ugodne učinke v obdobju starosti. Namen prispevka je predstaviti pregled literature

s področja preučevanja koristi gibalne aktivnosti za psihološko zdravje in kakovost življenja pri starejših odraslih. Slednji so v primerjavi z drugimi posamezniki bolj dovzetni za različne težave v duševnem zdravju, kot sta depresija in anksioznost. Številne presečne in eksperimentalne študije, o katerih razpravljamo v prispevku, ugotavljajo, da je aktivni življenjski slog ključen za preprečevanje ali zmanjšanje težav v duševnem zdravju ter izboljšanje kakovosti življenja pri starejši populaciji.

Ključne besede: *duševno zdravje, gibalna aktivnost, kakovost življenja, pozna odraslost*

INTRODUCTION

It is becoming increasingly apparent that successful aging is possible if people maintain certain healthy lifestyle habits throughout their lives (Mora, 2013). Among these habits, we also include physical activity (PA). According to the World Health Organization (WHO, 2015), a regular PA among older people is highly recommended for the promotion of an active lifestyle: older adults should participate in at least 50 minutes of moderate intensity and 75 minutes of vigorous intensity level PA per week.

In a number of recent studies, PA has been identified as a key factor for improving health and quality of life in older adults (Daskalopoulou et al., 2017; Gill et al., 2013; Murtagh et al., 2014). As population aging is progressing rapidly in many industrialized countries, it is important to understand the relationship between PA and the physical and mental well-being of older people (King & King, 2010).

The health benefits of PA in older adults have been well established in the scientific literature (Musich, Wang, Hawkins, & Greame, 2017). Regular PA can reduce the morbidity and mortality from many chronic diseases, postpone disability and prolong independent living (Kokkinos, 2012; Warburton & Bredin, 2017). There is good evidence that being physically active reduces the risk of developing cardiovascular and metabolic disease through better control of blood pressure, cholesterol and waist circumference (Earnest et al., 2013). Physical activities and exercise programmes are important for building and maintaining bone density; they also improve neuromuscular capacity, increasing strength and muscle mass, which in turn may reduce the risk of falls (Meléndez-Ortega, 2007). PA is also associated with a reduction in age-related diseases such as dementia and Alzheimer's disease (Reiner, Niermann, Jekauc, & Woll, 2013). Conversely, prolonged sedentary behaviour is associated with deleterious health outcomes, including cardiovascular disease incidence and mortality, type II diabetes and cancer incidence (Biswas et al., 2015).

In addition to all the positive effects on physical health, there is growing evidence that PA is beneficial for mental health, well-being (Mochcovitch, Deslandes, Freire, Garcia, & Nardi, 2016; Netz, Wu, Becker, & Tenenbaum, 2005) and even cognitive functioning (Colcombe & Kramer, 2003; Gajewski & Falkenstein, 2016) in older

adults. Multiple studies have found a positive association between exercise and PA and the alleviation of symptoms of anxiety and depression (Lee et al., 2014; Lindwall, Rennemark, Halling, Berglund, & Hassmén, 2007).

OBJECTIVES

The purpose of this contribution is to present an overview of empirical literature regarding the benefits of PA on mental health and well-being, the possible mechanisms explaining PA effects on mental health and the association between PA and quality of life in the elderly.

Electronic databases PubMed, PsycINFO, Scopus, and SPORTDiscus were searched for literature sources in May 2018 for the last two decades (between 1997 and 2017 inclusive). Different keywords were used: physical activity, exercise, mental health, quality of life, psychological well-being, older adults.

PHYSICAL ACTIVITY EFFECTS ON MENTAL HEALTH AND WELL-BEING IN OLDER ADULTS

The aging process is associated with an increased prevalence of both physical and mental health concerns (Wrosch, Schult, Miller, Lupien, & Dunne, 2007). Poor mental health is an important consideration for older adults, since it seems to be a substantial component of the perceived quality of life and can also affect health status (Cho, Martin, Margrett, MacDonald, & Poon, 2011).

Depression is the most common mental disorder in this age group, which affects approximately 5 % and 7 % of the world's older population (WHO, 2016) although significant depressive symptoms (which do not meet the diagnostic criteria for major depression) are much more prevalent among community-dwelling old adults. Mental health problems in later life are under-identified by health professionals and by older people themselves; therefore, to promote well-being in later life, it seems crucial to prevent or adequately address mental health problems. Given the high cost of health care and prescription medication, it is important to consider the relationships between the modifiable behaviours and lifestyles that might affect the mental health, such as PA (Parker, Strath, & Swartz, 2008).

Penninx and colleagues (2002) examined the exercise effects on emotional function in 438 older participants with high and low depressive symptomatology. After an 18-month walking program, a significant reduction of depressive symptoms (assessed by the Centre for Epidemiologic Studies Depression scale – CES-D; Radloff, 1977) was reported for both persons with initially high and low depressive symptomatology, hinting at the possible antidepressant effect of PA. These findings illustrate that aerobic exercise may have significant beneficial emotional effects among the general older population. In a similar study conducted by Blumenthal et al. (1999), a 16-week

randomized controlled trial was performed to assess the effectiveness of an aerobic exercise program compared with standard medication for treatment of older patients with major depressive disorder. One hundred fifty-six men and women were assigned randomly to a program of aerobic exercise, antidepressants, or combined exercise and medication. Anxiety was assessed using the Hamilton Rating Scale for Depression (HAM-D; Linden, Borchelt, Barnow, & Geiselman, 1995) and the Beck Depression Inventory (BDI; Beck, Steer, & Garbin, 1988). The investigators demonstrated that exercise training program including supervised sessions of walking and jogging are equally as effective as a standard antidepressant therapy in reducing depression symptoms among older clinically depressed persons (Blumenthal et al., 1999). Some authors also emphasize that traditional treatments for depression such as psychotherapy and antidepressant medications are not effective for all patients, therefore, alternative approaches are recommended, especially the use of aerobic exercise (Blumenthal, Smith, & Hoffman, 2012).

In a recent meta-analytic study, Silveira and colleagues (2013) evaluated the effect of aerobic training and strength training as a treatment for depression in patients diagnosed with major depressive disorder. The meta-analysis concluded that physical exercise, mainly aerobic training, improves the response to depression treatment. However, the efficacy of exercise in the treatment of depression was influenced by age and severity of symptoms.

Mummery and colleagues (2004) examined the dose-response relationship between PA and mental health, comparing different levels of PA involvement. The study included 337 independent living older adults ranging from 55 to 89 years of age. Activity status was assessed using the Active Australia questionnaire, whereas health status was assessed using the 12-Item Short Form Health Survey (SF-12; Jenkinson, Chandola, Coulter, & Bruster, 2001). Participants in the moderately active group (150-420 minutes of PA per week) and highly active group (>420 minutes of PA per week) displayed significantly higher mental health status than those who were classified as inactive (< 150 minutes of PA per week) when controlling for physical health status. A meta-analytic study conducted by Conn (2010) synthesized depressive symptom outcomes of 38 supervised and 22 unsupervised PA interventions among healthy adults. The obtained findings showed that both supervised and unsupervised PA interventions are effective in reducing depressive symptoms among adults without clinical depression.

In a recent longitudinal study, the relationship between the quantity and type of PA and subsequent depression in 3,497 adults aged between 65 and 75 was examined. Total PA was measured using the Physical Activity Scale for the Elderly (PASE; Washburn, McAuley, Katula, Mihalko, & Boileau, 1999), while depressive symptoms were measured by the Patient Health Questionnaire (PHQ-9; Martin, Rief, Klaiberg, & Braehler, 2006). The participants who practised the highest levels of PA and whose activity profile included athletic activity were at lower risk for depression in older age (Joshi et al., 2016).

Given the prevalence of depressive symptoms and the low rate of diagnosis among older adults, the promotion and maintenance of moderate-intensity aerobic PA could be

a recommended way for improving psychological well-being for all older people (Bridle, Spanjers, Patel, Atherton, & Lamb, 2012; Lee et al., 2014; Mummery, Schofield, & Caperchione, 2004).

Watanabe and colleagues (2000) examined the effect of an acute PA program of different exercise conditions on the level of anxiety among older adults. Seventy-three healthy participants were randomly assigned to either water exercise group or land exercise group. The state of anxiety was assessed before and after the exercise. The obtained results showed that both exercise groups scored lower on anxiety after exercise, suggesting that the participation in these types of exercise can help to reduce anxiety levels in older persons. Moreover, in a meta-analytic review of cross-sectional studies, a greater amount of physical exercise was associated with preferable levels of both positive and negative effects (Arent, Landers, & Etnier, 2000). Stubbe and colleagues have found that accumulating more PA is correlated with higher satisfaction with life (Stubbe et al., 2007).

The effects of regular PA on the person's mood have mainly been studied using aerobic exercise but evidence indicates that other types of exercise, such as strength or flexibility training, can also reduce depressive symptoms, while less consensus exists with respect to anxiety symptoms (Peluso & Andrade, 2005). Chodzko-Zajko and colleagues (2009) reported that both aerobic exercise training and resistance exercise training produce clinically meaningful improvements in depression in clinical patients, with response rates ranging from 25 % to 88 %, whereas the findings are less consistent among the seniors without clinical depression.

In a recent systematic review, Mochcovitch and colleagues (2016) evaluated the efficacy of regular PA on anxiety symptoms in older adults without anxiety disorders. All analysed studies have shown that regular and supervised PA was directly related to decreased anxiety symptoms in older individuals. The authors concluded that regular PA may be effective for reducing anxiety levels in older adults, however, more studies are needed to identify the ideal PA modality, frequency, duration and intensity for optimizing the positive effects of exercise on anxiety in this population.

Although research consistently points to an inverse correlation between exercise and mental health, some authors indicated conflicting results it this relationship, emphasizing the importance of instrumentation used to measure PA (Parker et al., 2008). Due to lower complexity and relative low cost, most studies use subjective techniques, such as questionnaires, to assess PA. In general, subjective methods are accurate for measuring structured exercise but tend to overestimate moderate and vigorous PA and underestimate sedentary behaviour (Dyrstad, Hansen, Holme, & Anderssen, 2014). On the other hand, objective PA measures (i.e., pedometers, accelerometers) are increasingly used to evaluate the relationship between PA and mental health in older adults (Fox, McKenna, & Davis, 2007; Loprinzi, 2013). Parker and colleagues (2008) examined the relationship between one week of PA and mental health among 84 adults aged 55 to 87 as measured by pedometers, accelerometers and the PASE questionnaire. Objective PA assessment instruments were more sensitive in detecting the small but significant relationship between PA and mental health (in terms of positive affect, negative affect,

and satisfaction with life) relative to the subjective PA measurement technique. These results suggest that objective instruments may be preferable for assessing PA patterns among older adults. A study conducted by Loprinzi (2013) examined the association between accelerometer-assessed PA and depression symptoms among 708 older adults (65+ years). They wore an accelerometer for at least four days, and completed data on the study covariates along with depression, as assessed by the PHQ-9. After controlling for age, gender, race-ethnicity, body mass index, marital status, education, comorbidity index, and physical functioning, both light, and moderate-to-vigorous intensity PA was associated with lower depression levels.

MECHANISMS UNDERLYING THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND MENTAL HEALTH

The relationship between PA and mental health has been widely investigated and several hypotheses including neurobiological, psychological and social mechanisms have been proposed to explain this relationship (Deslandes et al., 2009; Lubans et al., 2016). Physiological mechanisms that are often discussed involve monoamine, endorphin and thermogenic hypothesis (Mikkelsen et al., 2017). Exercise is associated with the increased synthesis and release of both neurotransmitters and neurotrophic factors, and these increases may be associated with neurogenesis, angiogenesis and neuroplasticity (Matta Mello Portugal et al., 2013). The monoamine hypothesis proposes that exercises lead to balanced levels of neurotransmitters (such as dopamine, serotonin, and norepinephrine) which are usually imbalanced in people suffering from depression. Therefore, this hypothesis suggests that PA can work in a similar way as anti-depressants, medications that can help relieve symptoms of depression (Toups et al., 2011). The thermogenic hypothesis states that PA facilitates an increase in body temperature. Consequently, the increased temperature in specific brain region can lead to a more relaxed state, and, consequently, mood enhancement (DeBoer, Powers, Utschig, Otto, & Smits, 2012). The endorphin hypothesis originated from runners experiencing a feeling of euphoria or high after long distances. It states that the release of β-endorphins in the brain following exercise produces a morphine-like effect which reduces the sensation of pain and provides a state of positive mood and an overall enhanced sense of well-being (Dishman & O'Connor, 2009).

Alternatively, psychological mechanisms for positive changes in mood and effect as a result of PA include the distraction hypothesis and the self-efficacy hypothesis (Peluso & Andrade, 2005; Shaw, Gorely, & Corban, 2005). The distraction hypothesis suggests that exercise distracts people from depressive worries and negative thoughts. Participating in PA or other distracting activities (e.g. relaxation, social contacts) gives people a break from daily hassles and stressors and provide the opportunity to relax and perhaps put things in perspective. (Peluso & Andrade, 2005). The self-efficacy hypothesis is centred on the notion that exercise brings better physical competence which results in positive feelings of achievement, increased sense of ability and self-confidence. While

these feelings are associated specifically to the exercise domain, it is hypothesized that they may generalize to other areas of life, resulting in an increase of psychological well-being (Shaw et al., 2005).

The social interaction hypothesis proposes that social interaction and support from other people in an exercise setting provides a significant proportion of the PA effect on mental health (Crone, Smith, & Gough, 2009). Research confirmed the relationship between social network ties and positive mental state in the older population, showing that people who are more socially connected tend to report greater emotional well-being compared to those who have fewer social ties (Litwin & Shiovitz-Ezra, 2011). Especially for some excluded groups, such as older people or people with depression, the opportunity for social interaction may be particularly important for their psychological health.

PHYSICAL ACTIVITY AND QUALITY OF LIFE IN OLDER ADULTS

An important component in determining the health status of an individual, particularly during the process of aging, is quality of life (QoL). QoL is a global, multidimensional construct representing overall relative satisfaction with life. The concept of QoL includes different domains such as functional ability, psychological well-being, social relationships, socioeconomic status, living environment, daily activities, health, cultural and ethical values (Bowling, 2005). Older adults are often more concerned with their QoL than their longevity *per se*, so improving and maintaining a high QoL assumes great importance among the elderly. Because QoL is adversely impacted by illness and disability, an improved physical function might be expected to cause a parallel increase in QoL (Fleg, 2012).

PA has been consistently associated with enhanced well-being and QoL in later life (Netz et al., 2005). Different studies conducted on older adults from the general population have found that physical exercise may improve social interactions, self-esteem and global QoL. Furthermore, it may also contribute to increased independence in activities of daily living in older adults (Taylor et al., 2004; Warburton & Bredin, 2017).

Flynn et al. (2009) have investigated the effects of exercise training on health status and QoL (assessed by the Kansas City Cardiomyopathy Questionnaire – KCCQ; Green, Porter, Bresnahan, & Spertus, 2000) in 2,331 older adults with heart failure. The intervention included usual care plus aerobic exercise training, consisting of 36 supervised sessions followed by home-based training, compared to usual care alone. The results demonstrate that the participation in an exercise training program provides a modest but statistically significant improvement in patient-reported health status and QoL compared with usual care. Similarly, Austin and colleagues (2005) aimed to determine whether a cardiac rehabilitation programme improved health-related quality of life of 200 patients with heart failure aged 60 to 89. Patients were randomised to one of two interventions, outpatient clinic based care (standard care) or clinic based care plus cardiac rehabilitation, including a 24-week of low resistance training. Health-related

quality of life was measured with the Minnesota living with heart failure questionnaire (MLHF; Rector, Kubo, & Cohn, 1993) and the EuroQoL questionnaire (Brooks & de Charro, 1996) at baseline and 24 weeks. Patients attending cardiac rehabilitation attained a significant improvement in health-related QoL compared to the patients in standard care.

To establish the association between PA and QoL in older adults, Vagetti and colleagues (2014) conducted a systematic review of the literature in the period between 2000 and 2012. In general, the studies included in this review showed a positive association between PA and many but not all domains of QoL. Results indicated that PA was often associated with the following QoL domains: functional capacity; general life autonomy; past, present and future activities; intimacy and mental health. These associations suggest that PA may promote physical independence as well as essential mental health aspects of QoL.

Although the results of recent literature suggest a positive and consistent influence on the relationship between PA and QoL in older adults, the mechanisms underlying these effects are still unclear. Self-efficacy – commonly defined as the belief in one's capabilities to achieve a goal or an outcome, appears to be an important variable that mediates the relationship between PA and QoL (Vagetti et al., 2014). Researchers have consistently shown that when PA is associated with significant increases in self-efficacy, improvements in health-related QoL are most likely to occur (Mudrak, Stochl, Slepicka, & Elavsky, 2016). Efficacy beliefs also predict the behaviour and performance of older adults with mobility problems, balance difficulties, and are therefore at risk for falls (Rejski & Mihalko, 2001; McAuley et al., 2011).

Furthermore, exercise and PA have been proposed to impact the QoL and well-being through their moderating and mediating effects on constructs such as self-concept and self-esteem. In particular, physical self-esteem has repeatedly been shown to be an important mental health status indicator in the context of PA and QoL relationship (Phillips, Wójcicki, & McAuley, 2013).

PA and QoL play an important role in enhancing successful aging (Choi, Lee, Lee, & Jung, 2017). According to Vagetti et al. (2014), evidence on the impact of PA frequency and intensity on QoL domains is still limited. Therefore, further longitudinal and intervention studies are needed to better understand this influence.

CONCLUSION

Growth in the elderly population means an increased risk for poor mental health outcomes such as depression, anxiety, and serious constraints on the QoL among older people. In recent years, a substantial body of literature has tried to explain the mental health benefits of PA in older adults. Although most of the studies discussed in this article report an inverse, dose-dependent relationship between PA participation and mental health outcomes, some questions remain unanswered, such as the right amount of exercise (e.g. frequency and intensity) to improve this protective response. Also, further

studies using objective PA measures can contribute significantly to establish clear links between the amount of exercise and specific mental health benefits in older adults.

Regular PA and exercise are important for healthy aging and are beneficial for chronic disease management. However, there is evidence that as people age, they tend to exercise progressively less and most of them do not meet the recommended PA levels, particularly those living in less affluent areas (McPhee et al., 2016). Greater consideration of all psychological benefits of physical exercise is needed among health and exercise professionals working with the elderly. The main challenge is to find effective ways to encourage older adults to increase PA and reduce sedentary behaviour. It is therefore important to develop strategies to overcome barriers to exercise and stimulate participation in such activities that will be adapted to the needs and interests of older individuals.

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REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

FINAL SCIENTIFIC AND PROFESSIONAL CONFERENCE "MOTOR SKILLS OF PRESCHOOL CHILDREN"

Zagreb, Croatia, August 31st, 2018

At the end of the summer, the 4th scientific-professional conference "Motor Skills of Preschool Children" was held in Zagreb. It was organized by the Faculty of Kinesiology, and the Education and Rehabilitation Faculty, University of Zagreb, under the patronage of the President of the Republic of Croatia, the Ministry of Science and Education, and The Agency for Education of the Republic of Croatia. It was attended by over 200 participants.

The purpose of the Conference was to present the results of the UIP-2014-09-5428 project titled "Motor Skills of Preschool Children" funded by the Croatian Science Foundation and was carried out under the guidance of Assist. Prof. Sanja Šalaj, Ph.D. The objectives of the project were as follows:

a) Evaluating preschool children's motor skills in the Republic of Croatia,
b) Determining differences in the motor skills of children with different levels of physical activity and involvement in the implementation programs,
c) Defining the connections between motor development and other areas of childhood development (socioeconomic and linguistic development),
d) Establishing the impact of parental support on children's physical activity and the degree of their physical activity at the level of children's motor abilities and
e) Determining the impact of different training programs on motor skills and abilities of pre-school children.

The project included 1,500 girls and boys aged 3 to 7 from various parts of Croatia. The measurements were carried out in two parts, in the first part the parents were requested to fill out a questionnaire, while in the second part the children's motor skills were assessed with two sets of tests to determine their motor status. In the third year of the project implementation, certain effects of exercise programs on the children's motor skills were also analysed.

The problems of inadequate motor competencies and overweight children from the kinesiological, medical, health, sociological and psychological point of view, were presented by plenary lecturers from Croatia (Rea Fulgosi-Masnjak, Ph.D., Giovan Armano, Saša Krstulović, Ph.D., Biljana Trajkovski, Ph.D., Sara Cobal, Frane Žuvela, Ph.D.), from Slovenia (Gregor Jurak, Ph.D. and Saša Pišot, Ph.D.) and from Serbia (Boris Popović, Ph.D.) in order to present important findings from the field of child's development.

A wider selection of motor skills that are already included in the project, such as intervention training and exercises, will enable children to choose from the sports activities that they master and enjoy. Acquiring motor competencies and one's own satisfaction with physical activity is not given enough emphasis, however, it should be recognized as an important factor for the child's healthy / unhealthy behaviour and physical activity / inactivity.

The results of the project undoubtedly provide important information for educators, teachers, pedagogues, kinesiologists, health workers and parents advising how to encourage children›s motor development in order to achieve multiple benefits and healthy active lifestyle. Therefore, projects like this are always welcome for professional public.

Saša Pišot

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

ZAKLJUČNA ZNANSTVENO-STROKOVNA KONFERENCA »MOTORIČKA ZNANJA DJECE PREDŠKOLSKE DOBI«

Zagreb, Hrvaška, 31. avgust 2018

Ob koncu poletja se je v Zagrebu odvijala 4. znanstveno-strokovna konferenca »Motorička znanja djece predškolske dobi«, ki je v organizaciji Kineziološke fakultete in Pedagoško-rehabilitacijske fakultete Univerze v Zagrebu ter pod pokroviteljstvom predsednice Republike Hrvaške, Ministrstva za znanost in izobraževanje ter Agencije za vzgojo in izobraževanje Republike Hrvaške, gostila preko 200 udeležencev.

Namen konference je bil predstaviti zaključne rezultate projekta UIP-2014-09-5428 »Motorička znanja djece predškolske dobi«, ki ga je financirala Hrvaška fundacija za znanost in je v obdobju od 2015-2018 potekal pod vodstvom doc. dr. Sanje Šalaj. Cilji projekta so bili:

a) vrednotenje motoričnih sposobnosti predšolskih otrok v Republiki Hrvaški,
b) prepoznavanje razlik v motoričnih spretnostih otrok z različnimi stopnjami telesne aktivnosti in vključenosti v vadbene programe gibalne/športne aktivnosti,
c) opredelitev povezav razvoja motorike z drugimi področji razvoja v otroštvu (socialnoekonomski in jezikovni razvoj),
č) ugotoviti vpliv starševske podpore na gibalno/športno aktivnost otrok in stopnjo njihove telesne aktivnosti na ravni motoričnih sposobnosti otrok in
d) prepoznavanje vpliva različnih programov usposabljanja na motorične spretnosti in gibalne sposobnosti predšolskih otrok.

Projekt je vključeval 1500 deklic in dečkov v starosti od 3 do 7 let iz različnih delov Hrvaške. Meritve so v okviru projekta potekale v dveh delih. V prvem delu so starši otrok izpolnjevali vprašalnik, v drugem delu pa so bili otroci deležni testiranja motoričnih spretnosti z dvema sklopoma testov za oceno njihovega motoričnega statusa. V tretjem letu izvajanja projekta so bili preizkušeni nekateri učinki programov vadbe na motorične spretnosti predšolskih otrok.

Problem nezadovoljivih gibalnih kompetenc in prekomerne telesne mase otrok, so plenarni predavatelji iz Hrvaške (dr. Rea Fulgosi-Masnjak, Giovana Armano, dr. med., dr. Saša Krstulović, dr. Biljana Trajkovski, Sara Cobal, mag., dr. Frane Žuvela), Slovenije (dr. Gregor Jurak in dr. Saša Pišot) in Srbije (dr. Boris Popović) izpostavili iz kineziološkega, medicinsko-zdravstvenega, sociološkega in psihološkega vidika ter predstavili pomembna dognanja iz področja otrokovega razvoja, v povezavi z gibalno/športno aktivnostjo in okoljem.

Širši nabor motoričnih znanj, ki so jih raziskovalci v obliki intervencijske vadbe v projektu že vključili, bo otrokom med drugim omogočil, da izberejo tiste gibalne/športne aktivnosti, ki jih dobro obvladujejo in v njih uživajo. Vzročnemu momentu pridobivanja gibalnih kompetenc in lastnega zadovoljstva v gibanju, se kot pomembnemu dejavniku za nadaljnje zdravo/nezdravo vedenje in gibalno aktivnost/neaktivnost, vse prepogosto ne daje dovolj poudarka.

Rezultati projekta nedvomno podajajo pomembne informacije za vzgojitelje, učitelje, pedagoge, kineziologe, zdravstvene delavce in starše o tem, kako spodbujati otrokov motorični razvoj, za doseganje koristi na številnih področjih in zdravega aktivnega življenja, zato so tovrstni projekti za strokovno javnosti vedno dobrodošli.

Saša Pišot

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

SUMMER SCHOOL ON HEALTHY AND ACTIVE LIFESTYLE "HALS − HEALTHY AND ACTIVE LIFESTYLE 2018"

Piran, Slovenia, 3rd–9th September 2018

The successful Summer School HALS2018, held between 3 and 9 September 2018, was organized by the Science and Research Centre Koper and the Euro-Mediterranean University (EMUNI). The summer school saw the participation of numerous renowned lecturers from Slovenia, Italy, Austria and Germany.

The first day opened with the presentation of Boštjan Šimunič, Ph.D., focusing on positive aspects and limitations of the technology for measuring quantity and intensity of movement / sports activity. The participants received ActiGraph accelerometers and wore them until the last day of the Summer School when they analysed and showed the data in the final report.

The second day was focused around theories and lectures delivered by Rado Pišot, Ph.D., Marco Narici, Ph.D., Pietro di Prampero, Ph.D., and Tadej Debevec, Ph.D. The topics presented included kinesiology as a science in the field of a healthy and active lifestyle, transfer of knowledge from space research to earth research, research models in aging and motor inactivity, as well as cardiovascular adaptations in extreme living environments such as hypoxia and long-term horizontal bed rest / physical inactivity. In the afternoon, the participants visited the Mediterranean Health Centre where the content of sports diagnostics and rehabilitation was introduced. The participants were able to check their motor skills and receive an interpretation of their results. The afternoon activities included the visit to Bonifika Sports Park and the PANGeA Active Park for the elderly and the new construction of sandy volleyball courts along the Grand Canal. This allowed the students to learn about the spatial possibilities of urban environment for active population in the Municipality of Koper.

The third day of the Summer School was marked by our host lecturers Carlo Reggiani, Ph.D., Marco Narici, Ph.D., and Nandu Goswami, Ph.D. They presented the latest findings of their research in the areas of muscular adaptations from the point of view of muscle fibres and neuromuscular connections and mechanisms of cardiovascular decline in old age. Boštjan Šimunič, Ph.D. showed muscular contractile properties in practice and presented the latest guidelines for muscular potentiation, peripheral and central fatigue, and the muscular adaptations that occur in the process of normal and pathological aging. In the afternoon, the participants were invited to rowing in a multi-seat canoe.

Gianni Biolo, Ph.D., started the fourth day with his lecture on the meaning of a healthy diet during all periods of life. The lecture was followed by Milena Bučar, Ph.D., and Bojan Butinar, Ph.D. who highlighted the importance of Mediterranean diet and micronutrients for a healthy and active lifestyle. This was followed by a workshop on preparation of a healthy Mediterranean meal and some other sports activities. The afternoon activity included a cycling trip to Sečovlje salt pans, combining sports and nutrition in practice.

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

The fifth day of the Summer School focused on neuroscience. Anita Hokelmann, Ph.D., and Kathrine Rehfeld, Ph.D., lectured on neuro-plasticity of the brain in cyclic and acyclic movements. Later on, Uroš Marušič, Ph.D. presented the findings of his research in the field of motion-cognitive interventions aiming to improve functional and cognitive abilities of older population. In the afternoon, Anita Hokelmann, Ph.D., and Kathrine Rehfeld, Ph.D. presented the practical content of motion learning and new guidelines for dance to promote neuro-plasticity of the brain. The day wrapped up with Nordic walking workshop. Through the activity, the participants were discovering Fiesa and the slopes of Pacug with stunning views of the Strunjan bay.

The sixth day of the Summer School included theoretical presentations on the treatment of patients after a stroke. Pietro Paolo Battaglini, Ph.D., presented the latest applications of neuro-feedback methods for BCI: brain-computer interfaces. The lecture was followed by Enrico Tongiorgi Ph.D. who introduced the Memori-net project where new guidelines for the treatment of patients after stroke are being formulated. The theoretical part was concluded by Paolo Manganotti, Ph.D. with an outline of treatments for patient after a stroke. Afternoon workshops were carried out by Uroš Marušič, Ph.D. and Boštjan Šimunič, Ph.D. The former presented the importance of measuring brain activity while simultaneously measuring equilibrium and walking for the needs of rehabilitation, while the latter focused on handling functional abilities with the help of simple and advanced measuring equipment. The last evening brought the participants to a final gathering, collecting impressions and establishing new friendships in the pleasant ambient of summertime Piran.

On the last day of the HALS2018 Summer School, participants presented the results of the whole-day measurement of motion / sports activity and passed a written and oral exam.

Given the encouraging feedback from the participants and the very successful organization of the first HALS2018 Summer School, the organizers suggested the date for the second HALS2019 Summer School, which is to be organized between 15th and 21st July, 2019.

We look forward to your participation.

Uroš Marušič and Saša Pišot

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

POLETNA ŠOLA O ZDRAVEM IN AKTIVNEM ŽIVLJENJSKEM SLOGU »HALS – HEALTHY AND ACTIVE LIFESTYLE 2018«

Piran, Slovenija, 3.–9. september 2018

Poletna šola HALS2018 je potekala v tednu od 3. do 9. septembra 2018 in bila zelo uspešno organizirana s strani Znanstveno-raziskovalnega središča Koper in Evro-sredozemske univerze EMUNI. Na poletni šoli so sodelovali številni priznani predavatelji iz Slovenije, Italije, Avstrije in Nemčije.

Prvi dan je dr. Boštjan Šimunič predstavil pozitivne aspekte in hkrati omejitve tehnologije merjenja količine in intenzivnosti gibalne/športne aktivnosti. Udeleženci poletne šole so prejeli ActiGraph pospeškometre in jih nosili vse do zadnjega dne poletne šole, ko so podatke analizirali in prikazali v končnem poročilu.

V drugem dnevu poletne šole HALS2018 so se v teoretičnem delu zvrstili predavatelji dr. Rado Pišot, dr. Marco Narici, dr. Pietro di Prampero in dr. Tadej Debevec. Predstavili so tematike umestitve kineziologije kot vede v področje zdravega in aktivnega življenjskega sloga, prenosa znanj iz vesoljskih raziskav na raziskave na Zemlji, raziskovalnih modelov pohitrenega staranja in gibalne neaktivnosti ter srčno-žilnih adaptacij v ekstremnih življenjskih okoljih, kot so hipoksija in dolgotrajno horizontalno ležanje/gibalna neaktivnost. V popoldanskem času so udeleženci obiskali Mediteranski center zdravja, kjer jim je bila predstavljena vsebina športne diagnostike in rehabilitacije. Na najnovejših napravah so udeleženci lahko preverili svoje gibalne sposobnosti in prejeli ustrezna poročila ter interpretacijo rezultatov. V sklopu popoldanskih aktivnosti pa so si ogledali še Športni park Bonifika z Aktivni gibalnim parkom PANGeA za starejše ter novogradnjo peščenih igrišč za odbojko ob kanalu Grande ter ob tem spoznavali prostorske možnosti urbanega okolja za aktivno prebivalstvo v Mestni občini Koper.

Poletna šola je v tretjem dnevu gostila dr. Carla Reggianija, dr. Marca Naricija in dr. Nanduja Goswamija. Predavatelji so podali najnovejše ugotovitve svojega raziskovalnega področja in s tem udeležencem predstavili področja mišičnih adaptacij z vidika mišičnih vlaken in živčno-mišičnih povezav ter mehanizme srčno-žilnega upada v starosti. S praktičnega vidika je dr. Boštjan Šimunič prikazal meritve mišičnih kontraktilnih lastnosti in podal zadnje smernice mišične potenciacije, perifernega in centralnega utrujanja ter nasploh mišičnih adaptacij, ki se zgodijo v procesu normalnega in patološkega staranja. Popoldansko aktivnost pa so popestrili z veslanjem v večsedežnem kanuju.

Dr. Gianni Biolo je pričel s predavanjem četrtega dneva, v katerem je podal pomen zdrave prehrane v vseh obdobjih življenja. Sledili sta predavanji dr. Milene Bučar in dr. Bojana Butinarja, ki sta izpostavila pomen mediteranske prehrane in mikronutrientov za zdrav in aktivni življenjski slog. Sledila je delavnica priprave zdravega mediteranskega obroka in gibalne/športne aktivnosti. Popoldansko aktivnost pa smo začinili še s kolesarskim izletom v Sečoveljske soline in tako združili gibalno aktivnost in prehrano.

Peti dan poletne šole je bil osredotočen na nevroznanstvene vsebine. Dr. Anita Hokelmann in Dr. Kathrine Rehfeld sta predavali o nevro-plastičnosti možganov pri cikličnih in acikličnih gibanjih. Nadaljeval je dr. Uroš Marušič, ki je predstavil ugotovitve raziskav na področju gibalno-kognitivnih intervencij za izboljšanje funkcionalnih in kognitivnih sposobnosti starejše populacije. V popoldanskem času sta Dr. Anita Hokelmann in Dr. Kathrine Rehfeld predstavili praktične vsebine gibalnega učenja in nove smernice učenja plesa za spodbujanje nevro-plastičnosti možganov. Aktiven dan se je zaključil z delavnico nordijske hoje, kjer smo poleg tehnike nordijske hoje spoznavali še Fieso in klifnata pobočja Pacuga s čudovitimi pogledi na Strunjanski zaliv.

Šesti dan poletne šole je bil namenjen teoretičnim predstavitvam obravnave pacientov po možganski kapi. Dr. Pietro Paolo Battaglini je prikazal najnovejše aplikacije nevro-feedback metod za potrebe komunikacij med človekom in robotom (»BCI: brain-computer interfaces«). Nadaljeval je dr. Enrico Tongiorgi, ki je predstavil projekt Memori-Net, kjer se oblikujejo nove smernice obravnave pacientov po možganski kapi. Teoretični del je zaključil dr. Paolo Manganotti z orisom problematike obravnave pacienta po možganski kapi. Popoldanske delavnice sta vodila dr. Uroš Marušič in dr. Boštjan Šimunič. Dr. Marušič je prikazal pomen merjenja možganske aktivnosti med sočasnim merjenjem ravnotežja in hoje za potrebe rehabilitacije, dr. Šimunič pa je predstavil obravnavo funkcionalnih sposobnosti s pomočjo enostavne in napredne merilne opreme. Zadnji večer pred zaključkom so se udeleženci srečali na zaključnem druženju, ker so ob zakuski in prijetnem glasbenem ambientu poletnega Pirana zbirali vtise in spletali nova prijateljstva.

Zadnji (sedmi) dan poletne šole HALS2018 so udeleženci predstavili rezultate celotedenskega merjenja gibalne/športne aktivnosti ter opravili pisni in ustni izpit.

Zaradi spodbudnih povratnih informacij udeležencev in nasploh zelo uspešno organizirane prve poletne šole HALS2018, so organizatorji predstavili datum druge poletne šole HALS2019, ki bo organizirana v tednu od 15.do 21. julija 2019. Vljudno vabljeni.

Uroš Marušič in Saša Pišot

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

CONFFERENCE REPORT "SKELETAL MUSCLE: FROM MOLECULES TO FUNCTION"

Padua, Italy, 1st October 2018

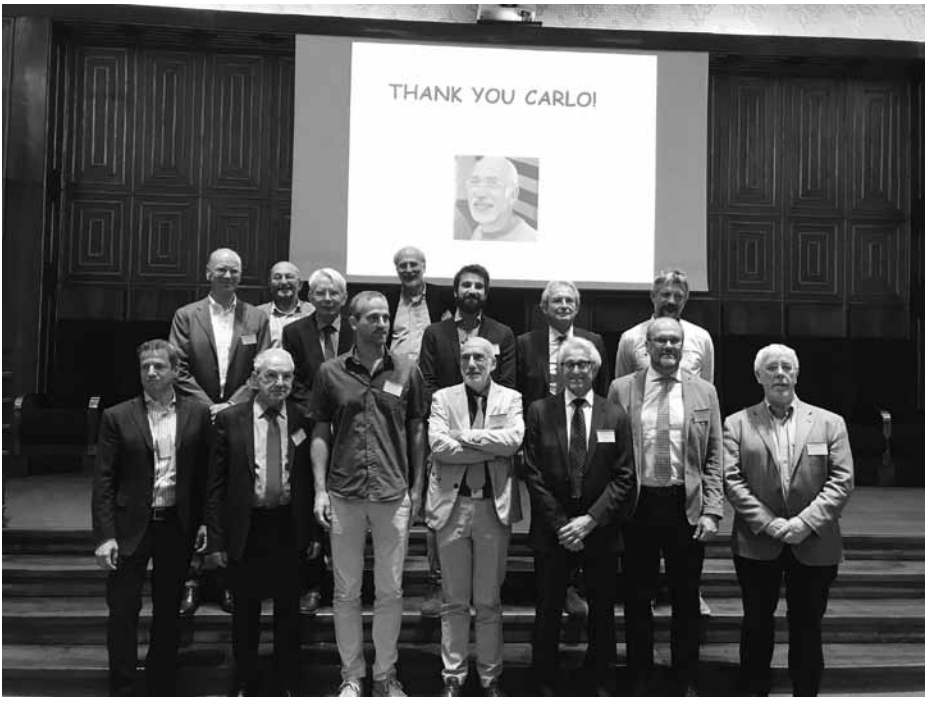
It was a handful of students, almost eight centuries ago, who founded one of the first universities in Europe: 1222 marked the birth of the University of Padua, destined to welcome teachers such as Galileo Galilei and Andreas Vesalius (from: http://www.unipd.it).

Prof. Carlo Reggiani began his academic journey at the University of Pavia back in 1974. After spending 5-years learning in the laboratory of prof. Paul Edman at the University of Lund, he was appointed as an Associate Professor at the University of Pavia in 1984 and in November 1999 he joined the Medical School staff as a full professor at the University of Padua, one of the oldest universities.

October 1st 2018 marked another great day in the life of the University of Padua and Carlo's friends and colleagues. Carlo celebrated his 70th birthday and announced his retirement. Along with attending the Conference devoted to his achievements, we had an opportunity to envisage his great achievements and anecdotes during the presentations by his friends, students and colleagues. The Conference was organised by his colleague and friend, Prof. Marco Narici, in Aula Magna of Palazzo Bo, a historical mecca of physicians. Saving the best for the last, Carlo's talk began with a story of Scheherazade.

The king Shahryar found out that his first wife was unfaithful to him. He thus resolved to marry a new virgin each day as well as behead the previous day's wife, so that she would have no chance to be unfaithful to him. He had killed 1,001 such women by the time he was introduced to Scheherazade. Once in the king's chambers, Scheherazade's sister asked her to tell a story during the long night. The king lay awake and listened to Scheherazade told her first story. The night passed by and Scheherazade stopped in the middle. The king asked her to finish, but Scheherazade said there was no time, as dawn was breaking. So, the king spared her life for one day to finish the story the next night. The following night, Scheherazade finished the story and then began a second, even more exciting tale, which she again stopped halfway through at dawn. Again, the king spared her life for one more day, so she could finish the second story. And so, the king kept Scheherazade alive day by day, and at the end of 1,001 nights, and 1,000 stories, the king had fallen in love with Scheherazade (summarised from: Scheherazade).

And similarly to the stories of Scheherazade, Carlo experimented in thousands of muscle fibres from animals, humans, young, old, athletic, sedentary, himself, etc. Pre-



paring each intact fibre under the microscope for 30-60 minutes to investigate its contractile properties. And finally, allowing time for one more. And another.

His work was enormous (more than 220 scientific articles, and more than 8000 citations) and we are proud to share bits of his academic career. We have collaborated in six scientific articles since 2008, reporting data from the studies where we listened, learned, discussed, and had fun.

> *We compared the responses of older and young men to 14 days of bed rest and subsequent rehabilitation. The effect of inactivity on muscle mass and function was greater in older men, whereas metabolic alterations were greater in young men. Recovery of preinactivity conditions occurred more slowly in older men. The results emphasize the importance of avoiding or minimizing the periods of inactivity in old age (Pišot, Reggiani, Šimunič, et al. J Appl Physiol, 2016).*

As we jointly discovered, it is important to know that we need to compensate for old age and to avoid periods of inactivity.

> *Dear Carlo, since your thirties, you have lost 6 kilos of muscle fibres. That is the exact amount found in this prosciutto. Most of muscle loss is due to decrease of*

daily physical activity, therefore you will need to increase it for what you will need this exercise T-shirt. To support your exercise, you will need to increase intake of certain carotenes, minerals and vitamins. You will find them in this bottle of olive oil; however, for the vitamin D you will need to expose yourself to the sun. Which we believe you will have no trouble during your retirement. Blood will distribute your nutrition to your new working muscle and for that purpose you will need to compensate for the lost blood. To compensate for plasma and erythrocyte volume you will need to ingest these two bottles of Malvasia and Refosco wine, respectively. (from the presentation of Rado Pišot and Boštjan Šimunič)

It was a great pleasure that our Institute for Kinesiology Research took part at this Conference and that you also cooperated with our Institute. Thank you, Carlo!

Boštjan Šimunič, Rado Pišot
and other members of the Institute for Kinesiology Research

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

POROČILO IZ KONFERENCE »SKELETNE MIŠICE: OD MOLEKULE DO FUNKCIJE«

Padova, Italija, 1. oktober 2018

Bila je le peščica študentov, ki je pred skoraj osmimi stoletji ustanovila eno prvih univerz v Evropi. Leto 1222 predstavlja rojstvo Univerze v Padovi, ki bo kasneje gostila tako pomembne učitelje, kot sta bila Galileo Galilei in Andreas Vesalius (povzeto po: http://www.unipd.it).

Prof. Carlo Reggiani je začel svoje akademsko pot na Univerzi v Pavii v Italiji leta 1974. Kasneje se je pet let izpopolnjeval v laboratoriju prof. Paula Edmana na Univerzi v Lundu na Švedskem, leta 1984 pa je bil imenovan za izrednega profesorja na Univerzi v Pavii. Novembra leta 1999 se je kot redni profesor pridružil osebju ene najstarejših univerz na Fakulteti za medicino in kirurgijo Univerze v Padovi.

1. oktober 2018 označuje še en pomemben dan za Univerzo v Padovi in za vse prijatelje in kolege Carla Reggianija. Ta dan je namreč hkrati praznoval 70. rojstni dan in odhod v pokoj. Ob konferenci, posvečeni njemu v čast, smo imeli priložnost podoživeti nekaj utrinkov iz njegove bogate kariere skozi predstavitve njegovih znanstvenih dosežkov pa tudi anekdot iz življenja, skozi oči njegovih prijateljev, študentov in kolegov. Konferenco je organiziral njegov prijatelj in znanstveni kolega prof. Marco Narici v t. i. Veliki predavalnici (Aula Magna) v znameniti univerzitetni palači Bo, ki je še danes neke vrste zgodovinska Meka vseh zdravnikov. Carlo je svoj nagovor na kongresu pričel z znano zgodbo o Šeherezadi:

Sultan Šahrijar je ugotovil, da mu je bila njegova prva žena nezvesta. Odločil se je, da se bo vsak dan poročil z novo devico, hkrati pa bo vsak dan dal obglaviti svojo ženo iz prejšnjega dne. Prepričan je bil, da bo lahko le tako preprečil svoji ženi nezvestobo. Do tistega dne, ko so mu kot novo nevesto predstavili Šeherezado je ubil že tisoč in eno dekle. Ko je bila Šeherezada v sultanovih sobanah, je svojega moža prosila, če se lahko pred usmrtitvijo še poslovi od svoje sestre in on ji je to dovolil. Sestra je Šeherezado prosila, naj pove kakšno zgodbo, da bo dolga noč hitreje minila. Tudi sultan, ki je ležal poleg, je poslušal Šeherezadino prvo zgodbo. Noč je minila in Šeherezada je nehala pripovedovati, čeprav zgodba še ni bila končana. Sultan jo je prosil, naj zgodbo dokonča, vendar ga je ona zavrnila, da ni dovolj časa, saj se zunaj že dani. Sultan je sklenil, da jo bo pustil pri življenju še en dan, da bi lahko dokončala zgodbo naslednjo noč. Toda naslednjo noč, ko je Šeherezada prvo zgodbo končala, je takoj pričela pripovedovati drugo, še bolj zanimivo. Pripovedovanje te druge zgodbe je prav tako prekinila na sredini ob zori naslednjega dne. Šahrijar jo je ponovno pomilostil za en dan, da bi lahko ponoči dokončala pripoved druge zgodbe. Tako si je Šeherezada noč za nočjo podaljševala življenje z vedno novimi zgodbami. Ko je minila tisoč in ena noč in mu je povedala tisoč zgodb,

se je sultan Šahrijar zaljubil v Šeherezado in jo dokončno pomilostil. (povzeto po: Tisoč in ena noč)

Podobno kot je Šeherezada prepletala svoje zgodbe, je Carlo eksperimentiral z na tisoče mišičnimi vlakni živali, ljudi, mladih in starih, športnikov in ostalih in ne nazadnje samega sebe. Vsako vlakno posebej je pod mikroskopom pripravljal 30-60 minut, da bi lahko nato preveril njegove kontraktilne lastnosti. In vedno je našel čas za še eno … in še eno …

Njegovo znanstveno delo je ogromno (več kot 220 znanstvenih člankov, preko 8000 citatov) in ponosni smo, da smo lahko delček njegove akademske kariere. Od leta 2008 dalje smo sodelovali pri pripravi šestih znanstvenih člankov, v katerih smo poročali o rezultatih znanstvenih raziskav pri katerih smo poslušali, se učili, diskutirali in se tudi zabavali.

Primerjali smo učinke 14-dnevne popolne gibalne neaktivnosti v študiji »bed rest« med starejšimi in mlajšimi moškimi in rehabilitacije, ki je temu sledila. Učinek neaktivnosti na mišično maso in funkcionalnost je bil večji pri starejših, medtem ko so bile pri mlajših ugotovljene večje metabolne spremembe. Rehabilitacija po neaktivnosti je bila počasnejša pri starejših moških. Rezultati kažejo na velik klinični pomen skrajševanja period neaktivnosti pri starejših (Pišot, Reggiani, Šimunič, et al. J Appl Physiol, 2016)

Kot smo skupaj dognali, se moramo zavedati, da je potrebno starost kompenzirati in se izogibati obdobjem neaktivnosti.

Dragi Carlo, od tvojih tridesetih let si izgubil 6 kilogramov mišičnih vlaken. Natanko toliko jih je v pršutu, ki ti ga podarjamo. Izguba mišičnih vlaken je večinoma posledica upada dnevne gibalne aktivnosti, kar boš moral nadomestiti in pri tem naj ti bo v pomoč ta športna majica. Za boljšo vadbo boš moral povečati vnos nekaterih karotenov, mineralov in vitaminov, ki so vsi prisotni v tej steklenici oljčnega olja. Kljub temu pa boš moral poskrbeti še za zadostno količino vitamina D in se za to dovolj izpostavljati sončnim žarkom, kar sedaj, ko si v pokoju, ne bi smel biti problem. Kri bo hranila prenašala do tvojih na novo pridobljenih mišičnih vlaken in potrebno bo nekako dopolniti zalogo krvi. Da boš imel v prihodnje dovolj plazme in eritrocitov, boš moral zaužiti ti dve steklenici malvazije in refoška. (iz predstavitve Rada Pišota in Boštjana Šimuniča)

V veliko zadovoljstvo nam je bilo, da je lahko Inštitut za kineziološke raziskave ZRS Koper sodeloval na tej konferenci in hkrati, da si tudi ti del našega Inštituta. Hvala Carlo!

Boštjan Šimunič, Rado Pišot
in ostali člani Inštituta za kineziološke raziskave ZRS Koper

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

WORLD FOOD DAY 2018 – CONFERENCE ON "FOOD, NUTRITION, HEALTH"

Koper, Slovenia, 16th and 17th October 2018

Under the slogan "**We and Our Environment Together**" this Conference celebrated different milestones along the World Food Day 2018, namely, 150 years since the publication of the first Slovene cookbook by Magdalene Pleiweis, the 35th anniversary of European Centre for Peace and Development (ECPD, established by the United Nations University for Peace https://www.ecpd.org.rs/), the 10th anniversary of the European Declaration on Food, Technology and Nutrition for Health (EFTND, http://eftndeclaration.aaeuropae.org/), and the inauguration of the Mediterranean Institute for Environmental Studies (MIES) at the Science and Research Centre Koper (ZRS Koper). The Conference was jointly organized by ECPD, EFTN and ZRS Koper, hosted by Janez Podobnik M.D. (Director of ECPD Ljubljana), Prof. Peter Raspor, double Ph.D. (on behalf of EFTN Ambassadors) and Prof. Rado Pišot, Ph.D. (Director of ZRS Koper).

The first day of the Conference was focused on topics that addressed interesting views on the environmental impact on food production, the connection of food and health, and food and nutrition education in Slovenian schools, as well as training of nutritionists.

Although one session partly covered the issue of food contamination, there was a lack of contrasting topics on underappreciated bioavailable nutritional value of food from the biochemical perspective. Illustrative and central were two round-table sessions: The Connection between Environment, Food Production and Health, moderated by Janez Podobnik, M.D. and The Connection between Food, Physical Activity and Health, moderated by Prof. Rado Pišot. Both were very well prepared and informative for the public.

The second day was more hands-on, intended for the presentation of medium and large enterprises showcasing their food products under the title **Eat and Drink Slovenian**. The goal of the presentations was also to connect the producers directly to the consumers and political facilitators of development. At the end of the sessions, the presenters joined in a panel and addressed the received questions, which was excellently moderated by Janez Podobnik, M.D.

Prof. Peter Raspor, Ph.D., organized an outstanding Conference dealing with many aspects of Slovenian food (http://danhrane.ecpd.si/). Some 60 participants attended the events every day. However, the participation could have been broader since the Conference was well-structured and efficiently moderated. We strongly believe that the Conference covers topics that would be of interest for various experts on public health and healthy lifestyle, representatives from different Ministries and students from the fields of dietetics, nutrition, food-technology and food production.

Cécil Meulenberg

REPORTS AND REVIEWS/POROČILA IN OCENE, 135–150

SVETOVNI DAN HRANE 2018 – KONFERENCA »HRANA, PREHRANA, ZDRAVJE«

Koper, Slovenija, 16. in 17. oktober 2018

Pod sloganom »**Mi In Okolje Skupaj**« je imela konferenca namen obeležiti svetovni dan hrane, 150 letnico izida prve slovenske kuharske knjige izpod peresa Magdalene Pleiweis, 35 letnico ustanovitve Evropskega centra za mir in razvoj (ECPD) https://www.ecpd.org.rs/ in 10 let Evropske deklaracije o hrani in prehrani (EFTN) http://eftndeclaration.aaeuropae.org/. Hkrati je bil ob tej priložnosti inavguriran tudi Mediteranski inštitut za okoljske študije (MIOS), ki deluje v okviru Znanstveno-raziskovalnega središča Koper. Konferenco so organizirali Evropski center za mir in razvoj (ECPD), Znanstveno-raziskovalno središče Koper (ZRS Koper) in ambasadorji EFTN, ki so jih zastopali Janez Podobnik, dr. med, direktor mednarodnega inštituta ECPD za trajnostni razvoj Ljubljana, prof. dr. Rado Pišot, direktor ZRS Koper in prof. ddr. Peter Raspor, v imenu ambasadorjev EFTN.

Prvi dan konference je bil namenjen sekcijam, ki so obravnavale zanimive poglede na vpliv okolja na pridelavo hrane, povezanost hrane in zdravja ter izobraževanje o hrani in prehrani v slovenskih šolah, pa tudi izobraževanju prehranskih strokovnjakov.

Vzporedno sta bili organizirani dve okrogli mizi: *Povezava med okoljem, pridelavo hrane in zdravjem*, ki jo je moderiral dr. Janez Podobnik in *Povezava med prehranjevanjem, gibanjem in zdravjem*, ki jo je moderiral prof. dr. Rado Pišot. Obe okrogli mizi sta bili dobro vodeni in zanimivi.

Drugi dan konference je bil z naslovom: »**Jejmo in pijmo slovensko**« namenjen predstavitvi manjših in srednje velikih slovenskih proizvajalcev hrane in njihovemu čim bolj neposrednemu povezovanju s potrošniki in s političnimi usmerjevalci razvoja. Zadnji del je bil namenjen predstavitvi projektov vezanih na hrano, ki potekajo v Sloveniji.

Konferenca, katere glavni organizator je bil prof. ddr. Peter Raspor, je predstavila mnoge zanimive in aktualne teme povezane s hrano. Približno 60 udeležencev, ki so zastopali znanost, proizvajalce hrane, izobraževanje in politične usmerjevalce razvoja, je bila pravzaprav preskromna udeležba za tako dobro strukturirano in organizirano konferenco. Menim, da bi se je lahko udeležilo več strokovnjakov javnega zdravja, promocije zdravja, ministrstev, pa tudi študentov študijskih programov s področja hrane, prehrane in zdravja.

Nadja Plazar

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.

2. General policy of Annales Kinesiologiae

Annales Kinesiologiae pursues the multi-disciplinary aims and nature of Kinesiology with the main goal to promote high standards of scientific research.

a) Reviewing: Each manuscript, meeting the technical standards and falling within the aims and scope of the journal, will be subjected to a double-blind peer-review by two reviewers. Authors can propose up to two reviewers for revision of their work and also up to two reviewers they would like to avoid.

The referees are chosen by the Editors. Assessments by the referees will be presented anonymously to the author and will be returned to the author for correction. The corrected copy of the manuscript, with the list of corrections on a separate page, should be returned to the responsible Editor.

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e) The authors are obliged to prepare two **abstracts** – one short abstract in English and one (translated) in Slovene language. For foreign authors translation of the abstract into Slovene will be provided. The content of the abstract should be structured into the following sections: purpose, methods, results, and conclusions. It should only contain the information that appears in the main text, and should not contain reference to figures, tables and citations published in the main text. The abstract is limited to 250 words.

f) Under the abstract a maximum of 6 appropriate **Keywords** shall be given in English and in Slovene. For foreign authors the translation of the key words into Slovene will be provided.

g) The **main text** should include the following sections: Introduction, Methods, Results, Discussion, Conclusions, Acknowledgement (optional), and References. Individual parts of the text can form sub-sections.

h) Each **table** should be submitted on a separate page in a Word document after the Reference section. Tables should be double-spaced. Each table shall have a brief caption; explanatory matter should be in the footnotes below the table. Abbreviations used in the tables must be consistent with those used in the main text and figures. Definitions of symbols should be listed in the order of appearance, determined by reading horizontally across the table and should be identified by standard symbols. All tables should be numbered consecutively Table 1, etc. The preferred location of the table in the main text should be indicated preferably in a style as follows: *** Table 1 somewhere here ***.

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j) References

The journal uses the Harvard reference system (Publication Manual of the American Psychological Association, 5th ed., 2001). see also: http://www.apastyle.org). The list of references should only include work cited in the main text and being published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text. References should be complete and contain up to six authors. If the author is unknown, start with the title of the work. If you are citing work that is in print but has not yet been published, state all the data and instead of the publication year write "in print".

Reference list entries should be alphabetized by the last name of the first author of each work. Titles of references written in languages other than English should be additionally translated into English and enclosed within square brackets. Full titles of journals are required (no abbreviations).

Examples of reference citation in the text

One author: This research spans many disciplines (Enoka, 1994) or Enoka (1994) concluded...

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Three to five authors:
a) first citation: Šimunič, Pišot and Rittweger (2009) found... or (Šimunič, Pišot & Rittweger, 2009)
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Only the first author is cited: Di Prampero et al. (2008) or (Di Prampero et al., 2008).

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Examples of reference list:
The style of referencing should follow the examples below:

Books:
Latash, M. L. (2008). Neurophysiologic basis of movement. Campaign (USA): Human Kinetic.

Journal articles
Marušič, U., Meeusen, R., Pišot, R., & Kavcic, V. (2014). The brain in micro- and hypergravity: the effects of changing gravity on the brain electrocortical activity. European journal of sport science, 14(8), 813-822. DOI: 10.1080/17461391.2014.908959.
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 Erpić, 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

The main manuscript document should be saved as a Word document and named with the first author's full name and the keyword *manuscript*, e.g. *"Pisot_Rado_manuscript.doc"*. Figures should be named as "*Pisot_Rado_Figure1", etc.*

The article should be submitted via e-mail: **annales.kinesiologiae@zrs-kp.si.**

Reviewing process communication will proceed via e-mail.

5. For additional information regarding article publication, please do not hesitate to contact the secretary of Annales Kinesiologiae.