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EDITORIAL

Could these be golden days for kinesiology!? If we take a look at today's lifestyle and the time that an average person spends being completely physically inactive, we can quickly find all the reasons for both poor performance and increased rate of illness (most of all chronic non-communicable diseases) of modern society. We have indeed entered an era when health analysis and risk reasons may be accompanied by the question of whether (and to what extent) you have a sedentary lifestyle and not only whether (and how much) you smoke!? Nowadays, the overall increase in physical inactivity is not only a problem of certain groups of society but of all, children and the elderly, an average recreation enthusiast or a potential professional athlete. This is something that we, kinesiologists are convinced of. The question that poses is to what extent the wider society is aware of this issue and the problems it brings along?

The present Editorial and the presentation of articles herein, therefore, deliberately begins at the very end, with an only seemingly less important report on the round table, titled »A KINESIOLOGIST IN THE LABOUR MARKET« which was organized by the Association of Kinesiologists of Slovenia and was held at the Scientific and Research Centre of the University of Primorska in the beginning of November 2016. The contents of the round table can be closely linked to the above-mentioned problems considering a wide spectre of needs, however, the round table can as well be connected with the 2016/2017 competitive skiing season which brought much success to our skier from Maribor, Ilka Štuhec. Our top skier especially likes to point out that her team consists of various professionals who are crucial in order to achieve such exceptional results, and among them, there is also a kinesiologist!

Nevertheless, this issue starts with an article which deals with the detailed examination of all the factors that cause numerous injuries on snowy slopes. Once again, an individual with his or her own characteristics is in the spotlight. Besides a mine of information offered by modern information technology, individuals are still not sufficiently prepared for taking efforts, are still ignorant of the ski slopes rules and regulations and are unreasonably tolerant to deviations from the security requirements that are established by professionals. The following articles further examine the role and importance of elementary movement patterns in motor development from childhood to old age, general physical efficiency and specifically targeted and tailored intervention programs for high-quality and independent lifestyle of the elderly etc. These are just as interesting and modern topics that concern every individual much more than we know. These topics, however, may be brought to the fore of interest only when we are old and incapable of performing daily tasks, when we need help and when we would give anything to overcome ... a flight of stairs!? »In the first half of our life we sacrifice our health in order to make money, in the other half we give money to recuperate health.« This is what was written by the French writer, philosopher and humanist François-Marie Arouet Voltaire (1694–1778) a long ago, yet, a man has not paid any attention to such warnings for centuries. In the articles published in this issue, we can again find evidence that the change only requires a shift in our belief, a real motivation and profes-

sional guidance. Thus, all tailor-made interventions as well as the environment in which we spend the autumn of our life can contribute significantly to more success, health, and, above all, satisfaction of an individual and the society.

Kinesiologists firmly believe in this. Our efforts to persuade the general public are only partially successful. Scientifiarticles, conferences, meetings of professionals, round tables and other public events, workshops and promotions are a regular feature of our work. We strive for even more efficiency and would like to raise awareness among large crowds. However, can only a fear of illness, powerlessness, weakness and loss be more efficient?

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

UVODNIK

Zlati časi za kineziologijo!? Če se ozremo na današnji način življenja in čas, ki ga povprečni posameznik preživi popolnoma gibalno neaktiven, lahko hitro najdemo razloge za vse slabšo učinkovitost in večjo obolevnost (predvsem s kroničnimi nenalezljivimi boleznimi) sodobne družbe. Resnično smo stopili v čas, ko je ob analizo zdravstvenega stanja in razloge tveganja morda potrebno že kar na prvo mesto postaviti vprašanje ali (in koliko) sedite in ne le ali (in koliko) kadite!? Splošni porast gibalne neaktivnosti danes ni le problem nekaterih specifičnih skupin temveč vseh, tako otrok kot starostnikov, povprečnega rekreativca ali potencialnega vrhunskega športnika. Kineziologi to vemo! Koliko pa je to vprašanje in iz njega izhajajoča problematika uzaveščena v širši družbi?

V tokratnem uvodniku kratko predstavitev prispevkov zato namerno začenjamo na koncu, pri le na videz manj pomembnem poročilu iz okrogle mize z naslovom »KINEZIOLOG NA TRGU DELA«, ki je v organizaciji Društva kineziologov Slovenije potekala na Znanstveno-raziskovalnem središču Univerze na Primorskem v pričetku novembra 2016. Vsebino okrogle mize namreč lahko tesno povežemo z zgoraj omenjeno problematiko na širokem polju potreb, lahko pa jo še posebej z navdušenjem povežemo tudi s tekmovalno smučarsko sezono 2016/2017 in uspehi mariborske smučarke Ilke Štuhec. Naša vrhunska športnica posebej rada izpostavi, da ima v ekipi poleg ostalih strokovnjakov, ki so nujno potrebni za doseganje tovrstnih izjemnih rezultatov, tudi kineziologinjo!

Sicer pa nabor tokratnih prispevkov pričenjamo ravno s podrobno obravnavo dejavnikov, ki povzročajo številne poškodbe na zasneženih pobočjih. Ponovno je v ospredju posameznik s svojimi značilnostmi. Ob številnih informacijah, ki mu jih nudi sodobna informacijska tehnologija, še vedno ni dovolj pripravljen na napore, je nepoučen o redu na smučišču in nerazumno toleranten do odstopanj od strokovno uveljavljenih zahtev varnosti. Vloga in pomen elementarnih gibalnih vzorcev v gibalnem razvoju od otroštva do starosti, splošne gibalne učinkovitosti ter posebej usmerjenih in prilagojenih intervencijskih programov za kakovostno in neodvisno življenje starejših odraslih, kar preučujejo naslednji prispevki, so ravno tako zanimiva in sodobna tematika, ki se slehernega posameznika dotika veliko bolj kot se danes zavedamo. Morda stopi v ospredje interesa šele takrat, ko nam je v starosti onemogočeno opravljanje vsakodnevnih opravil, ko smo potrebni pomoči in ko bi dali vse, da bi lahko premagali … nekaj stopnic!? »Polovico življenja dajemo zdravje za denar, drugo polovico pa denar, da bi ponovno pridobili zdravje« je, že dolgo tega, zapisal francoski pisatelj, filozof in humanist François-Marie Arouet Voltaire (1694–1778), pa vendar na ta zgodnja opozorila človek stoletja ni reagiral. V člankih, objavljenih v tokratni številki revije, lahko ponovno najdemo dokaze, da je za spremembo potreben le premik v prepričanju, pravi motiv ter strokovna usmeritev. Tako prilagojene intervencije kot okolje, v katerem preživimo jesen življenja, lahko pomembno prispevajo k uspešnejšemu, zdravemu, predvsem pa zadovoljnemu posamezniku in družbi.

Kineziologi smo v to prepričani. Naša prizadevanja, da bi prepričali tudi laično javnost so le delno uspešna. Znanstveni prispevki, konference, strokovna srečanja, okrogle mize in drugi javni dogodki, delavnice in promocije so stalnica pri našem delu. Želeli pa bi si še večjo učinkovitost in dvig zavedanja med širšimi množicami. Ali so res lahko bolj učinkoviti le strah pred boleznijo, nemoč, slabost in izguba?

prof. dr. Rado Pišot,
glavni in odgovorni urednik

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FACTORS AFFECTING ACCIDENTS ON SKI HILLS (Slovenian Case)

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ABSTRACT

Safety on the licensed ski slopes in Slovenia, like in many other winter countries, is a complex notion involving, in addition to ski slope owners and operators, several governmental agencies and functionaries, such as inspectors, supervisors, police, medical staff, and others. We cannot assign blame for accidents to them. Our research, in agreement with the Inspectorate of the Republic of Slovenia responsible for Internal Affairs and the Police Academy, focuses on the causes for skiing accidents. We found out that a skier plays an important role in safe-guarding his/her own safety as well as that of fellow skiers on the ski slopes. Obligations of the skier using a licensed ski slope are described in 10 internationally endorsed FIS Rules of Skiing. We obtained data on ski accidents for three consecutive ski seasons between December 2012 and April 2015. We studied whether or not the skiers followed FIS regulations and whether or not they adequately safeguarded their own safety. We also studied who is most often responsible for ski accidents.

Key words: *safety on ski slopes, causes of accidents, skier, skier's fault.*

VPLIVNI DEJAVNIKI NESREČ NA SMUČIŠČU

IZVLEČEK

Varnost na smučiščih je zelo kompleksen pojem. Zanj so pristojni številni organi- nadzorniki, upravljavci, policija in drugi. Vendar pa krivde za nastanek nesreč ne smemo pripisati njim. Izsledki dosedanjih raziskav in našega raziskovanja, ki smo ga opravili s soglasjem Inšpektorata RS, pristojnim za notranje zadeve in Policijsko akademijo kažejo, da nesrečo v večini primerov povzroči smučar s svojim ravnanjem. Največjo odgovornost za lastno varnost in varnost ostalih smučarjev na smučišču nosi smučar sam, njegove dolžnosti pa so opisane v 10 mednarodno sprejetih smučarskih FIS pravilih. Podatke o nesrečah smo zbrali in obdelali za obdobje smučarskih sezon v letih 2012/2013, 2013/2014 in 2014/2015. Zanimalo nas je, če smučarji upoštevajo predpise in dovolj dobro poskrbijo za svojo varnost. Preverili smo tudi, kdo je najpogosteje odgovoren za nastanek nesreč na smučišču.

Ključne besede: *varnost na smučišču, vzroki za nesrečo, smučar, krivda smučarja*

INTRODUCTION

Safety on ski slopes is a complex and difficult-to-define term. It does not depend only on the ski slope's operations, safety supervisors, and technical conditions that a ski slope is required by law to satisfy; it is also strongly affected by the behaviour of the ski slope's clients, i.e., the skiers themselves. All these factors represent risks for potential skiing accidents to occur (Burton, Brown & Fischer, 1984; Haegeli, Gunn, & Haider, 2012).

Scott and Steiger (2013) studied in detail the external factors that influence the development of skiing destinations in Europe as well as North America, and concluded that the environment depends on climate change. Artificial snow is one of the possible solutions to ever-decreasing snow fall; however, a low client base, i.e., low attendance on ski slopes or difficulties in obtaining funding for the purchase and installation of artificial snow equipment often preclude this solution. Furthermore, Simpson, Gössling, Scott, and Hall in Gladin (2008) state that the production of artificial snow is relatively costly, since it requires a significant amount of energy, the production of which causes an increase in global warming and accelerates the melting of glaciers. Jahn (2005) mentions an interesting technological advance introduced to several glaciers in Austria where these were covered with special white-coloured plastic covers that keep the snow at a constant temperature thereby slowing down the melting of glaciers.

Kipp (2012) describes skiing as a unique activity that requires a certain level of body equilibrium and skill for a proper execution. Joubert (1978), the pioneer of Alpine

skiing in France, explains that a skier is the central element in the execution of a ski turn. According to him, skiers executing a ski turn must remain in steady equilibrium while seeking support from the surface material on which they ski.

According to ZVSmuč (2016, page 2), "a ski run/piste is a section of a ski slope that is dedicated to skiing and is adequately equipped with signage, secured, as well as maintained with regard to its purpose and separated from other areas". A ski run/piste must be equipped with cautionary and informative notices as well signs on prohibitions and obligations.

Ski runs/pistes are classified with various colours for a designation of the level of difficulty. The green colour represents ski runs/pistes for beginners with lateral and downhill slopes not exceeding 25% and the red colour represents intermediate ski runs/pistes with lateral and downhill slopes not exceeding 40%. The steepest and the most demanding ski runs/pistes for which the largest lateral and directional slopes exceed 40% are identified in black (Deutscher Skiverband, 2016). "It is the responsibility of all skiers themselves to evaluate their own skiing ability and choose ski runs/pistes that are appropriate for their skills" (Guček et al., 2011). Kipp (2012) is of the opinion that it is the responsibility of individual skiers to evaluate the available information on the ski runs/pistes of a given ski area before they actually embark on them.

Similarly, Köhne, Kusche, Schaller, and Gutsfeld (2007) concluded that the majority of injured skiers during a six-year period at the German ski resort Garmisch-Partenkirchen used the new model of skis with accentuated side curve (carving skis) and that the type of injury has changed significantly since the introduction of the new ski model. They compared two groups of skiers: a group that used carving skis and a group that skied with traditional ski models. Of specific interest were the differences in the number of injuries to individual body parts between the two groups and they found that the carving skis group suffered a significantly higher number of injuries on the trunk as well as upper and lower extremities than the group that skied on traditional skis.

Mechelen, Hlobil, and Kemper (2012) stress that the classification of sports' injuries depends on the definition of a given sport injury as well as the participation in a given sport. In their opinion the statistical data on sport injuries should be normalized to one hour of a given sport activity. The authors also introduced a model that allows the determination of the causes of sport's injuries and proposed that the level of a given injury should be categorized on the basis of the following seven categories: (i) type of injury; (ii) length of medical care; (iii) type of medical care; (iv) amount of time prevented from practising a given sport activity because of the injury; (v) loss of time from work; (vi) long-term bodily injury; and (vii) financial cost related to medical care. In addition, one needs to define all the causes and mechanisms that influence and act as source of injuries. The last part of the model deals with solutions that may in the future diminish the risk of injuries.

Hu, Baker, and Baker (2009) confirm that the causes of minor and serious injuries are difficult to determine, because they are influenced by various factors, such as the number of skiers on the ski slope, level of difficulty of the ski run/piste, the number of skiing days, and other factors. They note that their investigation of conditions on North

American ski slopes showed that the number of accidents increased during the period from the years 2000 to 2005, despite a decrease in the number of skiers during the same period. Moreover, they also note that hospitals providing data on the number of injuries in various sports' categories do not give a sufficiently large emphasis on skiing.

Caine and Maffulli (2005) and Onik, Szopa, Domagalska-Szopa, Knapik, and Sieroń-Stołtny (2014) have divided accident risks into two categories: non-material and material. Non-material risks of ski accidents include the skier's age, gender, and level of skill, while material risks are influenced by the quality of the skiing equipment, the use or non-use of helmets, and the special characteristics of the ski run/piste. The authors postulate that these two risk categories can lead to ski injuries. The seriousness of the ski injury is evaluated according to the model introduced above. Onik et al. (2014) arrived at the conclusion that the largest number of injured skiers with regard to their age fell within the group of children and youngsters below the age of 16, while the majority of accidents, according to these authors as well as to Caine and Maffulli (2005), can be attributed to falls of skiers that are the fault of the skiers themselves.

McBeth, Ball, Mulloy, and Kirkpatrick (2009) carried out an interesting study of ski injuries that occurred on Canadian ski areas during ten successive ski seasons from 1996 to 2006. They note that a significantly higher number of accidents occurred to skiers who used newer ski equipment. They also surmised that environmental factors play a large role in the number of accidents and proclaim that the afternoon skiing period is the most critical daily period on ski slopes because during that period of the day the quality of snow is the lowest and, on top of this, the skiers, after several hours of skiing, are physically and mentally tired and do not react to danger with the habitual alertness and speed with which they would react in the morning.

Goulet et al. (1999) studied children whose age was below 12 who were skiing at the Canadian ski resort Quebec City during the 1995/96 ski season. They noted that at that time, despite its popularity among the population and the use of traditional ski models, skiing in terms of bodily injuries ranked immediately after hockey. Furthermore, they found that the main causes of ski accidents resulting in bodily injuries were: inappropriate equipment; inadequate knowledge of skiing; low skiing skill level; and use of rented equipment. They also identified the high risks that skiers who rent ski equipment were faced with because of lack of experience with the rented equipment. They established that continuing instruction as well as skill improvement are the key components in the quest to decrease the risk of accidents in skiing and they recommended that beginners in skiing be thoroughly informed on how to deal with ski equipment and on the general rules of, and appropriate behaviour on, ski slopes.

We gave special consideration to serious ski accidents resulting in death. According to an article The Protective Effects of Helmets in Skiers and Snowboarders, these types of accidents are relatively rare in the ski world (Ruedl, Kopp & Burtscher, 2011) and neither recreational nor professional skiers are generally aware of the risks for this type of accident to happen (Williams, 2016). Unfortunately, the awareness of skiing etiquette as well as the appropriate behaviour on ski slopes are on a disappointingly low level among skiers.

Based on a study carried out on the Austrian ski slopes during the ski season 2009/10 and presented in the article Impact of Ski Helmet Mandatory on Helmet Use on Austrian Ski Slopes by Ruedl, Brunner, Kopp & Burtscher (2011) a conclusion can be reached that fatal ski accidents are rare and that the main cause of these accidents is head trauma, self-inflicted by the skier's irresponsible behaviour, such as not wearing a ski helmet while skiing.

As mentioned above, the causes of ski accidents can be attributed to a variety of factors. Williams et al. (2007) and Hildebrandt et al. (2011) place great emphasis on the behaviour of skiers as well as on honouring international ski regulations. Several organizations have been active in this area. Among them, it is worth mentioning the American organization called the Pennsylvania SafeKids Coalition that makes children aware of the importance of ski equipment. In this regard, the biggest impression on children was made by comparing a human head with a coconut that was smashed to pieces in a heavy blow representing a ski accident when no safety equipment such as a ski helmet was used.

After seeing the coconut experiment, all the children committed to wear a ski helmet while skiing. Alexander and Raub (2003) praised this programme pointing out that the knowledge and the understanding which the children acquire during theoretical and practical ski instruction are of great importance. Based on this finding, Hildebrandt et al. (2011) opined that schools as well as other educational institutions based in countries promoting skiing should put more emphasis on discussing safety issues on the ski slopes. We wholeheartedly agree with these authors, since children as well as beginners in skiing, similarly to skilled adult skiers, are all at risk of injury on ski slopes. We believe that an introduction of better schooling in skiing techniques as well as the obligations of all participants on ski slopes would diminish the number of ski accidents and serve to curtail situations that increase the risk of accidents. Of course, the prevention of skiing accidents does not end with teaching the skiers the rules and the etiquette of good behaviour on ski slopes. For example, Tuli et al. (2010) have shown that facial injuries resulted primarily in adult skiers who fell accidentally or collided with another skier on the ski run/piste. They strongly recommended a sensible solution that would prevent or at least alleviate facial injuries, namely the use of a ski helmet during skiing.

Williams et al. (2007) have reported on the importance of using a ski helmet in relationship to brain trauma. A helmet can to a certain degree alleviate the consequences of a ski accident; however, they do not see a ski helmet as the ultimate solution. Rather, they suggest that the best approach to accident prevention is an unconditional honouring of the FIS rules in conjunction with a controlled speed limit on ski slopes. To prevent the most serious bodily injuries Onik et al. (2014) recommend to all skiers the wearing of ski helmets irrespective of their skill level. Caine and Maffulli (2005) also suggest the use of ski helmets for reducing the number of ski injuries and, in addition, recommend the use of wrist shields, appropriate behaviour, and a skiing speed adjusted to the skill level of individual skiers.

All the authors quoted the good reasons presented above for strengthening and improving safety conditions on ski slopes. We believe that the learning process of children

at a young age is very important, because the knowledge that they gain at that time will serve them well throughout their lifetime. Therefore, we strongly support the activities of organizations and projects in Slovenia, such as "Schoolchildren on Skis" that are focused on educating youngsters regarding the rules and codes of behaviour on the ski slopes.

It should be noted, however, that the knowledge of rules and regulations is a necessary but not sufficient safety guarantee for an individual skier on ski slopes. In our opinion, adequate ski equipment as well as a tuned and well-conditioned body that is ready for vigorous sport activity are also of significant importance. This point was of interest to Whelan, Gass, and Moran (1999) who studied the influence of warming-up before skiing on decreasing the risk of skiing accidents. They concluded that a series of stretching exercises has a very beneficial effect, not only on the skiing ability itself but also on the reaction time in situations in which a body that is not properly warmed up would respond sluggishly and this could potentially lead to an accident.

Skiers using Slovenian ski slopes must: (i) follow the so-called ZVSmuč Law (Zakon o varnosti na smučiščih, 2016 – Ski Safety Act, 2016); (ii) honour the international FIS regulations; and (iii) behave following the principle of mutual respect and understanding between themselves and other skiers. They may use the ski slopes in a manner that does not threaten or injure themselves and other skiers, or damage the equipment on the ski slope. In addition, they must adjust their speed as well as the direction of skiing to the ski slope conditions, and they must overtake other skiers allowing sufficient separation between themselves and the skier they are passing. It should also be noted that the amount of alcohol in a skiers' blood is by law limited to 0.24 milligram per litre of exhaled air and that the use of ski helmets is mandatory for all skiers below the age of 14 years.

A skiing accident is defined as an incident that occurs as a result of skiing or some other sport activity on the ski slope and involves at least one skier who either dies, is injured, or causes material damage to the ski slope equipment (ZVSmuč, 2016, page 2). Skiing accidents are divided into the following four categories: (i) accidents without bodily injuries that may involve damage to the ski slopes' equipment, and will not be discussed in this paper; (ii) accidents with minor bodily injuries; (iii) accidents with serious bodily injuries; and (iv) fatal accidents. A wide variety of skiing accidents are possible. For example, the responsibility for the accident may lie with the operator of the ski slope and equipment or with the skier who did not follow the international FIS regulations; the accident may have been caused by a malfunction of the ski lift; or the cause for the accident may be something else, for example the weather conditions. The operator of the ski slope must keep records of skiing accidents, enforce safety standards, maintain the ski slope equipment, and organize the manpower as well as the operation of the ski slope.

RESEARCH QUESTION

The safety considerations for ski slopes have several components. Some authors conclude that the new style "carving skis" has had an effect on the number of ski accidents (Burtscher et al., 2008; Dingerkus & Mang, 2002; Hörterer, 2004; Köhne et al., 2007; Sabeti, 2013). Others (Caine & Maffulli, 2005; Goulet, Régnier, Grimard, Valois, & Villeneuve, 1999; Hu et al., 2009; McBeth et al., 2009; Onik et al., 2014) have tried and some of these have succeeded in proving that accidents can also be caused by other factors, such as the condition of the ski run, environmental factors, ski equipment, skills and the physical condition of the skier, warming up before skiing, etc. Furthermore, several researchers, when studying the causes of an accident, place great importance on the skiers' knowledge and understanding of the international FIS regulations (Williams et al., 2007; Hildebrandt et al., 2011).

We now get to the important question on the cause of the steady increase in the number of accidents on the ski slopes. Are skiers only innocent victims of circumstances or are they themselves responsible for the increase as a result of a lack of understanding of the risks of skiing and their ignorance of the international FIS regulations applicable to ski slopes? A discussion about these questions will serve as a general overview of the accidents on Slovenian ski slopes during the ski seasons 2012/13, 2013/14, and 2014/15. We analysed our data for the three ski seasons and compared our conclusions with those of previous studies by other authors. Our study has contributed to an understanding of the safety and security conditions on Slovenian ski slopes and highlighted possible concrete improvements. Because we had a somewhat incomplete access to data regarding the circumstances surrounding the skiing accidents, we propose that a record is kept over the skier's equipment (ski model and manufacturer, presence of a helmet and its manufacturer) as well as other pertinent characteristics of the accident, such as weather conditions and snow quality, in order to get a more thorough overview of skiing accidents in the future ski seasons. Moreover, to date, we have not noted any study on Slovenian ski slopes that would evaluate the skiers' knowledge of FIS regulations.

The following questions were addressed in our evaluation of the safety standards on Slovenian ski slopes:

- Are there any statistical differences among the causes of ski accidents with minor bodily injuries?
- What is the age of the skiers involved in skiing accidents to determine which age group of skiers contributes to the largest number of accidents?
- What is the age of skiers with respect to the causes of accidents with minor bodily injuries?
- What is the influence of the age of the skiers on the severity of the accidents?
- Are there any statistical differences between the age of foreign skiers and local skiers in accidents with minor bodily injuries?
- Is there a correlation between the number of days of ski slope operation and the number of ski accidents?

– How do weather conditions affect the number of ski accidents?
– Is there a correlation between the number of accidents with minor bodily injuries and the causes of the accident?

METHODS

In our study we used a descriptive method based on local and international literature. In agreement with the General Police Office we analysed their statistical data on ski slope accidents and we also acquired some data from the Inspectorate of the Inspectorate for Internal Affairs of the Republic of Slovenia. We used the methodology of an explanatory case study that is based on a thorough description and study of the available data for each individual situation. We determined and explained the cause – effect relationship among the accidents occurring on Slovenian ski slopes. For our study we chose an analytic method in which we show the acquired data in a tabular or graphic format.

We collected our data from the evidence gathered from accidents with minor bodily injuries by the Inspectorate for Internal Affairs of the Republic of Slovenia and for accidents with severe bodily injuries, as well as for fatal accidents recorded by the Slovenian Police. The statistical results were verified with the Statistical Package for Social Sciences (SPSS), namely, with the statistical methods, the chi-square goodness of fit test, the Mann-Whitney U test, and the Kruskal-Wallis H test.

Skiers, Included in the Research

Our data sample consisted of skiers who were involved in skiing accidents on Slovenian ski slopes during three successive ski seasons: 2012/2013, 2013/2014, and 2014/2015, i.e., for a period from December 2012 to April 2015. The accidents are split into three categories: minor accidents, resulting in light bodily injuries; serious accidents, resulting in serious bodily injuries; and fatal skiing accidents. As shown in Table 1, the total number of injured skiers on the 47 Slovenian ski slopes during the three seasons was 2,804. Of these, 2,683 suffered minor bodily injuries and 121 severe bodily injuries, of which 4 were fatal.

Table 1. Number of accidents

Ski Season Type of accident	2012 / 2013	2013 / 2014	2014 / 2015	Total number of accidents for three seasons
Minor accidents	1,070	648	965	2,683
Serious accidents	40	28	49	117
Fatal accidents	2	1	1	4
Total # of accidents per ski season	1,112	677	1,015	2,804

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs* and from the *Police Academy.*

In the cohort of 2,683 minor injuries, 2,349 injured skiers were the residents of Slovenia, while 334 were from abroad (177 from Croatia, 69 from Hungary, 61 from the UK, and 27 from various other countries).

The ages of the injured skiers ranged from 2 years to 87 years. For greater clarity we split the age range into 8 age groups, as indicated in Fig. 1.

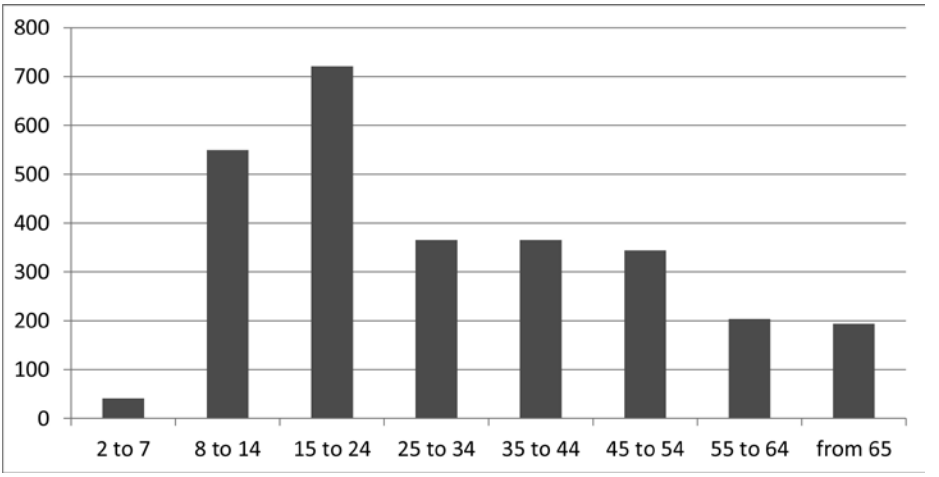

Figure 1. Number of accidents by age (Source: Authors, based on the data obtained from the Inspectorate of the Republic of Slovenia for Internal Affairs and from the Police Academy).

The highest accident rate occurred in the 15 to 24 age group of skiers (721 of 2,804 skiers or 25.9% of the total). Children in the 8 to 14 age group also form a relatively large accident rate of 550 (19.8%) of injured skiers. Next in size are two age groups (25 to 34 and 35 to 44) that represent 365 (13.1%) injured skiers each. The age groups of (45 to 54) and (55 to 64) consist of 344 (12.4 %) and 204 (7.3%) injured skiers, respectively. Skiers in the over 65-year age group were involved in 194 (7.0%) accidents, while children in the 2 to 7 age group had the lowest accident rate with 41 (1.5%) injured skiers. The total number of accidents for all age groups listed above adds up to 2,784, noting that we could not get the age data for 20 skiers injured in 20 ski accidents.

RESULTS

Official reports, in addition to the skiing injuries caused by the skiers to themselves (self-inflicted injuries), list 24 other causes of accidents. Based on the reports recorded for ski accidents with minor bodily injuries, we conclude that by far the largest component of these accidents falls into the category of self-inflicted injury. As evident from Table 2, the self-inflicted injuries amounted to about 50% of all minor injuries that happened during each of the three seasons analysed in our study.

Table 2. Number of minor accidents

Ski season **Accidents**	**2012 / 2013**	**2013 / 2014**	**2014 / 2015**	**Total for three seasons**
All **minor accidents** irrespective of fault	1,070 (100%)	648 (100%)	965 (100%)	**2,683 (100%)**
Minor accidents	588 (55%)	320 (49,4%)	520 (53,9%)	**1,428 (53,2%)**

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

Thus, during the three seasons (from December 2012 to April 2015), of the 2,683 skiers with minor injuries 1,428 (or 53.2%) of them had injurious falls that they caused themselves and the injuries were categorized as self-inflicted and minor. We summarize that a study of the 121 serious accidents (including the 4 fatal ones) would result in a similar conclusion; however, we cannot state this categorically because the data on the causes of serious accidents were not available to us. We recommend that this question be investigated to establish whether or not the probability for serious ski accidents as a result of skier error and lack of skill appropriate for a particular ski run is roughly the

same as the sum of the probabilities of serious accidents caused by all other possible causes.

A closer look into the data for the three ski seasons reveals, as summarized in Table 3, that the number of days of operation from December 2012 to April 2015 was highest during the 2012/13 ski season, amounting on the average to 47.1 days per ski slope or a total of 2,215 days for all 47 ski slopes. The 2013/14 ski season was the shortest of the three seasons studied with on average 26.2 ski days per ski slope and a total of 1,230 days for all 47 ski slopes. The following 2014/15 ski season showed some improvement over the second one with an average of 35.4 days per ski slope and a total of 1,665 days.

Table 3. Number of average operational days and total number of skiing accidents per operational day

Ski season	Average number of operation days per season	Number of skiing accidents per operational day
2012 / 2013	47.13	23.59
2013 / 2014	26.17	25.87
2014 / 2015	35.43	28.65

Source: Authors, based on the data obtained from the *Association of Ski Lift Operators of Slovenia* (GTZ) and the *Inspectorate of the Republic of Slovenia for Internal Affairs*.

Further study reveals on average a total (combined minor plus serious) of 23.6 accidents per day of operation on all Slovenian ski slopes combined during the first season studied, 25.9 accidents per day during the second season, and 28.7 accidents per day during the last season. These data clearly indicate a steady increase in the total average daily number of accidents from one season to the next.

As shown in Table 1, during the three seasons from December 2012 to April 2015 under our study we counted 2,683 accidents on Slovenian ski slopes that resulted in minor bodily injuries (minor accidents). In Table 4 we present for each individual season a comparison of the number of self-inflicted minor accidents with the number of accidents attributed to all other causes for each full day of the ski slope's operation.

Table 4. Number of minor injuries per operational day

Ski season Cause of accident	2012 / 2013	2013 / 2014	2014 / 2015
Skier's own fault	12.48	12.23	14.68
Other causes	10.22	13.64	13.97
Total number of accidents	**22.70**	**25.87**	**28.65**

Source: Authors, based on the data obtained from the *Association of Ski Lift Operators of Slovenia* (GTZ) and the *Inspectorate of the Republic of Slovenia for Internal Affairs*.

Irrespective of the accident causes, the total number of minor accidents during the 2012/13 season amounted to 22.7 per day of operation, during the 2013/14 season to 24.8 per day of operation, and during 2014/15 season to 27.2 per day of operation. It is clear that the highest total number of accidents occurred during the 2014/15 season, the last season in our study.

We verified our study using the chi-square test ($p = 0.196$; $\chi^2 = 5.99$; $df = 2$) whether or not from season 2012/13 to season 2014/15, the number of self-inflicted accidents in comparison to the accidents attributed to all other possible causes combined is increasing through the three seasons. Since the differences from season to season were not statistically significant and the connectivity of the variables is weak, we conclude that minor ski accidents from one season to the next cannot be characterized by a constant ratio between the number of self-inflicted accidents and accidents attributed to other causes.

Of special interest is the question focusing on the effects of the weather conditions on the number of skiing accidents. To investigate this issue, we concentrated on two time periods during which the ski slopes have the highest occupancy rate, namely during the winter school holidays (10 days) and Christmas – New Year holidays (10 days). The Weather Service of Slovenia summarized for us the weather conditions prevalent on the major Slovenian ski slopes during the two 10-day holiday periods for the three ski seasons included in our study.

Under the heading of weather conditions, we studied the wind speed, degree of clouding, height of new snow, presence of fog, and presence of rain. Data presented in Table 5 describe the number of minor accidents that occurred on the ski slopes of Slovenia during the period of Christmas – New Year 10-day holidays and winter 10-day school holidays for three ski seasons (2012/2013; 2013/2014; and 2014/2015) for a period from December 2012 to April 2015.

Table 5. Number of minor accidents for two ski periods

Ski season Ski period	2012 / 2013	2013 / 2014	2014 / 2015
Christmas – New Year holidays (10 days)	142	26	19
Winter school holidays (10 days)	134	158	314
Total number of accidents during the complete season	**1070**	**648**	**965**

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

It is shown that in the second (2013/2014) and third (2014/2015) season discussed in our study, the number of accidents during the 10-day school holidays exceeded those that happened during the 10-day Christmas – New Year holidays. Moreover, during the 10-day school holidays of the third season (2014/2015), the number of accidents amounted to almost a third of all accidents that occurred during the total season (i.e., 314 out of 965). A comparison of the weather conditions for the two holiday periods for a given ski season did not show any significant deviations. During the first ski season we noticed a difference in the average temperature of the ambient air (Christmas-New Year holiday: 0.1°C; winter holidays: -5.8°C); however, we cannot surmise that the higher air temperature during Christmas – New Year holiday caused a higher number of accidents. Even though we found a difference in the number of accidents between the second and the third ski season (Table 5), there were no large deviations in the weather conditions between the two seasons. Since there were no appreciable deviations in the weather conditions in the three ski seasons, we cannot postulate that weather conditions had an appreciable effect on the number of accidents for the individual seasons. A more thorough analysis of the seasons in which there are significant deviations in the weather conditions should be carried out and the conclusions should account for the number of skiers present on the ski slopes.

Of the total number of 2,683 minor accidents during the three ski seasons from December 2012 to April 2015 we obtained data on the causes for 2,314 accidents. The average age of the accident victims was 30.25 years. In **Table 6** we display the distribution of the accidents with regard to their cause based on the data available from the official records on ski accidents compiled on the sites of the accidents by the ski slope's supervisors and the police. Accident causes that appeared at least five times in the official records are specified in Table 6 as follows: (1) the skier fell because of his/her own fault; (2) represents the fall only; (3) the skier was stationary; (4) the skier had just started to move; (7) the skier skied at the tail end (of a group of skiers); (8) the skier

crashed (into a barrier); (10) the skier was stopping with a left turn or right turn; (12) the skier jumped; (15) the skier skied on a run marked with posts; (22) the skier collided with another skier; and (25) the skier was involved in an accident not listed above.

For example, accident category (25) typically includes a stationary skier; merging from the right or left; shadow skiing; rear skiing from the left or right side; passing; skiing in the reverse direction; lingering in a blind spot; sitting under a break-point; crossing the ski slope; skiing with an disconnected safety harness; skiing with unsuitable equipment; skiing with disconnected bindings; walking on the ski run without ski equipment; skiing on a closed ski run; sledding on a ski run; skiing on a ski run under the influence of alcohol or any other psychoactive substance; as well as any other cause of accident that has not yet appeared in the official documents.

Table 6. Number and percentage of light accidents

Designation	Cause of accident	Number of accidents	Percentage of total number	Rank average
(1)	Skier fell because of his/her own fault	1,440	62.2	1,127.28
(2)	Skier fell by no fault of his/her own	492	21.3	1,158.28
(3)	Skier was stationary	18	0.8	750.06
(4)	Skier had just taken off	29	1.3	1,139.53
(7)	Skier skied in the rear	16	0.7	1,431.53
(8)	Skier crashed	48	2.1	1,431.53
(10)	Skier was slowing down	50	2.2	1,432.30
(12)	Skier made a jump	33	1.4	1,157.99
(15)	Skier skied on a run marked with posts	49	2.1	982.83
(22)	Skier collided with another skier	28	1.2	1208.23
(25)	Other infrequent accident causes	111	4.8	1,250.18
Total number	**N/A**	**2,314**	**100.0**	**1,463.31**

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

We found a significant deviation for accidents caused by skiers who either were stationary or jumped resulting in ranks that were significantly lower than in other groups. This suggests that there are significant differences among the average age ranks for various causes of accidents ($p = 0.000$; $\chi^2 = 46.83$; $df = 10$).

Next, we focus on the average age of the accident victims who in their accidents suffered minor or serious (including fatal) bodily injuries and show results in Table 7

during the three consecutive winter seasons (2012/2013; 2013/2014; and 2014/2015) during the period from December 2012 to April 2015. We acquired age data for 2,779 skiers: data for serious accidents were available for all the age groups and we used the average value age values for each group. For the oldest group (age above 64 years) we did not have the maximum age, so we do not know the real median age. Based on our data for minor injuries, we assumed that in the severe injury category the average age for the highest age group was also 69 years.

Table 7. Number of accidents and age rank averages

Bodily injury	Number of accidents	Rank average	Sum of rank averages
Minor	2,658	1,386.43	3,685 142.50
Serious (incl. fatal)	121	1,468.33	177 667.50

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs* and from the *Police Academy.*

We then used the Mann-Whitney U test to determine whether or not the seriously injured skiers were on average older than the skiers in the minor injury category. For minor accidents the rank average is 1,386.43, while for serious (including fatal) injuries it is 1,468.33). Our calculations show that differences among various ranks exist; however, we cannot claim that they are statistically significant ($p = 0.272$; $U = 151,331.5$). This means that the average ages of the accident victims with respect to the type of injury (minor versus serious including fatal) are essentially the same.

Since foreigners skiing on Slovenian ski slopes during the three winter seasons from December 2012 to April 2015 represented 12.45% of the total population that was included in the category of minor accidents, we now touch upon foreign skiers in Table 8. The average age of all skiers (local and foreign) was 30.37 years.

Table 8. Number of accidents and age rank averages

Injured skiers	Number of accidents	Rank average	Sum of rank averages
Local	2,069	1,291.40	2 671 910.00
Foreign	582	1,449.00	843 316.00

Source: Authors, based on data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

The Mann-Whitney U test was used to investigate whether or not there were any statistically significant differences in the ages of foreign skiers and domestic skiers involved in minor accidents on Slovenian ski slopes. The investigation results in a rank average of 1,291.40 for local skiers and 1,449.00 for foreign skiers. This result is based on almost null risk suggesting a statistically significant difference in rank averages between local and foreign skiers ($p = 0.000$; $U = 530495$) and we conclude that the foreign skiers injured on Slovenian ski slopes during the past three ski seasons were, on average, older than the local skiers.

DISCUSSION

As stated above, Goulet et al. (1999) showed that two of the possible factors affecting the risk of a skiing accident are insufficient knowledge of and the fitness needed for skiing. In Slovenia, the responsible functionaries are not mandated to deal with these issues; however, despite this drawback, our study shows that in more than a half of all minor ski accidents the injuries suffered by the skier are self-inflicted, i.e., are the skier's own fault and caused by the skier's own error.

Our finding that the average number of accidents per day of ski slope operation is increasing from one season to the next is comparable to the situation on North-American ski slopes, as shown by Hu et al. (2009). Both studies showed a steady increase in the accident rates for minor and severe (including fatal) bodily injuries from one season to the next and suggest that for the benefit of tourism and recreational skiing, strong measures will be required to stop this disturbing trend on ski slopes around the world.

Based on our finding that the largest proportion of injuries is attributed to the age group of youngsters and young adults between the ages of 15 and 24 years, we propose an educational innovation: a ski examination that would likely improve the general knowledge of skiing rules and regulations. Educational institutions could introduce this project into special education curricula in a similar manner that they already use with cycling examinations in which Slovenian school-attending children must exhibit a certain knowledge of traffic rules to make their cycling safer.

The ski examination would consist of two components. The theoretical component would focus on the FIS regulations on skiing and the practical component would be part of the already existing programme under the auspices of winter schools in nature or special school days concentrating on various sport activities. Thus, ski examinations would promote skiing as a Slovenian national sport and would also decrease the number of ski accidents that are on ski slopes often caused by the skier's own fault.

Several years ago, one of the Slovenian elementary schools (Osnovna Šola Rovte) already introduced a pilot programme on formal ski education based on theoretical and practical examinations as part of winter school in nature. The programme was very successful and greatly improved children's knowledge of the international FIS rules and understanding of the consequences that can arise from carelessness and ignorance of the rules while skiing (Grom, 2009).

We also investigated the age of skiers for a given minor accident and found that more than one age group fell into a rank average that differed from the other ones. Based on these deviations it has become clear that there are statistically significant differences in rank averages and that age affects the cause of minor accidents. The effect of the age of injured skiers on the type of injury was also of interest to us and we found that both categories of injury (minor and serious including fatal) were roughly the same average age.

We need to mention foreign skiers who visit Slovenian ski slopes and represented 12.45% of the total cohort of skiers with minor injuries. Despite our findings that there are differences between the average age of foreign and local skiers, we believe that it would make sense to modernize the pictograms on ski trails as well as post information on ski slopes in the major foreign languages to decrease accident risks for foreign skiers.

Following the statements above, we believe that our research can contribute to the overall safety on Slovenian ski slopes. Regarding the findings, slopes should promote and ensure that all skiers understand the possible consequences that may result from crazy and irresponsible skiing. It would be advisable to modernize the pictograms that exhibit the FIS rules on Slovenian ski hills, since this move would definitely be attractive to local and foreign skiers, and a larger exposure of skiers to modern pictograms would eventually bring the international FIS rules into the skiers' sub-consciousness.

CONCLUSIONS

Based on the available literature and our results we cannot unequivocally state whether or not skiers on Slovenian ski slopes follow the international FIS ski regulations and the unwritten etiquette of skiing adequately. However, we can safely state that in the majority of ski accidents the skiers are responsible for causing their own injury as well as putting other skiers in danger. In concrete terms, the self-inflicted injuries during the last three seasons on Slovenian ski slopes accounted for 1,428 minor accidents out of a total of 2,683 minor accidents.

Safety on ski slopes is strongly affected by various educational activities for children attending elementary schools during the winter months. Research has shown that children and youngsters are often injured in accidents on ski slopes. Therefore, increasing the awareness of safety issues on ski slopes with a ski examination would clearly result in an improved level of understanding of the FIS rules. Special programmes on ski instruction in elementary schools would also improve the work of commercial ski schools and ski associations, thereby, contributing to an elevated level of knowledge of skiing, understanding the FIS rules, as well as appropriate behaviour on the ski slopes. This would result in increased safety on ski slopes and a concurrent decrease in the occurrence of skiing accidents.

To follow the safety situation on Slovenian ski slopes as well as skiing accidents trends, it would make sense to continue collecting accident statistics in future ski sea-

sons. This would allow us to verify whether or not the number of skiing accidents continues to increase; however, the various governmental agencies involved in the collection of accident data must unify their accident investigation processes and data keeping. This would give a more efficient supervision over the causes of skiing accidents and enable the same data analysis for both minor and serious (including) fatal accidents. As regular users of ski slopes, we believe that ski slope safety is of great importance for the promotion of skiing as a component of the tourism industry. Based on the modest opportunities for the development of the skiing industry in Slovenia, we cannot expect that Slovenia will become competitive with the skiing superpowers Austria and Italy in the near future. However, we believe that Slovenian ski slopes have an optimistic future, provided that the safety of the skiers is strengthened and modernized. This will decrease the number of skiing accidents and help to leave a positive impression on the visitors to the ski slopes.

As for future work, we believe that the area of ski slope safety would benefit from a study of the correlation between weather conditions, ski slope conditions, and skiing accidents, since these factors undoubtedly affect the occurrence of accidents and should be, in the future, recorded in accident reports.

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THE EFFECTS OF DIFFERENT EXERCISE-BASED INTERVENTIONS ON FUNCTIONAL FITNESS OF OLDER ADULTS

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ABSTRACT

Ageing is a multifactorial process associated with several irreversible functional and cognitive alterations of human body and determined by genetic and environmental factors. We aimed to investigate the effects of three physical activity interventions of 40 independently living older adults before and after a 3-month training period. Thirty female (69.6 ± 5.3 years) and ten male (70.6 ± 5.4 years) participants were randomly assigned into a physical exercise group (PEG; N = 9), a concurrent physical and cognitive exercise group (PEG + COG; N = 10), a physical exercise with additional 10 g of BCAA daily supplementation group (PEG+BCAA; N = 11), and a control group (CG; N = 10). All three groups performed the same physical exercise program for 12 weeks, three days a week for 45 − 60 minutes per session. Pre- and post-measurements were performed using a standardized functional fitness assessment tool for older adults i.e. Senior Fitness Test battery, upgraded with the Four Square Step Test (FSST) and Grip Strength Test (GST). When intervention groups were pooled, we found moderate to low improvements in the Chair Stand Up, Timed Up and Go, FSST and Six-minute Walk Tests (all P < .001). However, those improvements were intervention-specific with highest improvements found in the PEG for the FSST (P = .004) and Six-minute Walk Test (P = .004); in the PEG + COG for the Timed Up and Go Test (P < .001); and in

the PEG+BCAA for body mass (P = .012) and the Chair Stand Up Test (P < .001). Although the sample size was low, our study provides further evidence of different interventional exercise-based programs that can benefit the population of independently living older adults.

Keywords: *ageing, senior fitness test, frailty, cognition, diet, interventions.*

UČINEK RAZLIČNIH INTERVENCIJSKIH PROGRAMOV NA FUNKCIONALNO TELESNO PRIPRAVLJENOST ZDRAVIH STAREJŠIH ODRASLIH

IZVLEČEK

Staranje je pogojeno z več dejavniki, ki vodijo v funkcionalne in kognitivne spremembe, v močni soodvisnosti od genetskih in okolijskih dejavnikov. Cilj raziskave je bil preučiti učinkovitost treh 3-mesečnih gibalnih intervencij na 40 funkcionalno neodvisnih starejših preiskovancih, 30 žensk (69,6 ± 5,3 let) in 10 moških (70,6 ± 5,4 let). Preiskovanci so bili naključno razdeljeni v štiri skupine: gibalna intervencija (PEG; N = 9), gibalno-kognitivna intervencija (PEG+COG; N = 10), gibalno-prehranska intervencija z 10 gramov dodatkov BCAA dnevno (PEG+BCAA; N = 11) in kontrolna skupina (CG; N = 10). Vse tri intervencijske skupine so 12 tednov izvajale enako gibalno vadbo, tri vadbe na teden v trajanju posamezne vadbe 45-60 minut. Meritve smo opravili pred in po koncu intervencij z uporabo standardiziranega testa telesne pripravljenosti za starejše (Senior Fitness Test battery) in dodatno še testa štirih kvadratov (Four Square Step Test – FSST) ter testa silovitosti stiska pesti (Grip Strength Test – GST). Ko smo vse tri intervencijske skupine združili, smo ugotovili nizko do srednje napredovanje v testih vstajanja s stola, vstani in pojdi, FSST in hoje na 6 minut (vsi P < 0,001). Kljub temu pa smo ugotovili, da so bili napredki odvisni od specifične intervencije, saj so preiskovanci v skupini PEG najbolj napredovali v FSST (P = 0,004) in hoji na 6 minut (P = 0,004); v skupini PEG+COG v vstani in pojdi (P < 0,001); in v skupini PEG+BCAA v telesni masi (P = 0,012) in vstajanju s stola (P < 0,001). Navkljub nizkemu številu preiskovancev, smo dokazali vpliv različnih gibalnih intervencij, ki lahko pomembno prispevajo populaciji starejših, funkcionalno neodvisnih preiskovancev.

Ključne besede*: staranje, test telesne pripravljenosti za starejše, krhkost, dieta, intervencija*

INTRODUCTION

Ageing is a complex, multidimensional physiological process associated with a significant changes in the structure and function of an organism that occur as a result of time flow (Grimby & Saltin, 1983; Salthouse, 2009; Vandervoort, 2002; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003; Wertz & Dronkers, 1990). These age-related changes negatively affect a broad range of tissues, major organ systems and functions (Harman, 1981; Weinert & Timiras, 2003). More specifically, aging process triggers alterations in body composition (i.e. gradual accumulation of body fat and its redistribution to central and visceral depots), the loss of muscle mass or function (sarcopenia) and muscle weakness (dynapenia) along with other alterations in metabolic, cardiovascular or skeletal (osteopenia) systems (Baumgartner, 2000; Clark & Manini, 2008; Goodpaster et al., 2006; Haramizu, Ota, Hase, & Murase, 2011; Milanovic et al., 2013). With advancing age, these alterations become more pronounced, leading to physical and cognitive functions deterioration, which eventually increase prevalence of disability and mortality risk (Atkinson HH, 2007; Kallman, Plato, & Tobin, 1990; Kokkinos, 2012; Onder et al., 2002; Power, Dalton, & Rice, 2013; Salthouse, 2009; Topinková, 2008). It is also known that functional (and cognitive) loss can be preventable and even reversible through timely detection of physical weakness and appropriate intervention (Fried, Ferrucci, Darer, Williamson, & Anderson, 2004).

Physical inactivity, a main risk factor for overall mortality, leads to severe acute deterioration of muscle mass and function that could be also irreversible if not recognized and contrasted (Pisot et al., 2016). As both lifespan and aged population are increasing (Klenk, Rapp, Büchele, Keil, & Weiland, 2007), the emerging problem should represent identification of optimal and timely pharmacological, surgical, dietary, exercise and cognitive interventions that can mitigate ageing-related changes on a number of levels (Rowe & Kahn, 1997).

The effects of medical interventions are often centered and specific (i.e. affecting only the targeted health-related issues) and often cause serious side effects (Meador, 1994; Turjanski & Lloyd, 2005). Also, along with the high costs (i.e. lifelong drug usage) they might not represent the most desirable and effective strategies. In contrast, various exercise / physical activity interventions, when individually and professionally programed, have been proven to produce beneficial effects on physical and cognitive functions as well (Hallage et al., 2010; Hanson et al., 2009; Karavirta et al., 2011); even for population at-risk and / or patients (Flansbjer, Miller, Downham, & Lexell, 2008; Heyn, Abreu, & Ottenbacher, 2004; Morris, Dodd, & Morris, 2004). Accordingly, it is well established that regular physical activity is an efficient strategy for successful ageing (Kokkinos, 2012; Nelson et al., 2007; Taylor et al., 2004). Physical activity (PA) engagement increases life expectancy and improves the quality of life (Blair et al., 1989; Nelson et al., 2007; Paffenbarger, Hyde, Wing, & Hsieh, 1986). Further, it has been shown that PA reduces all-cause mortality (Blair et al., 1989; Kampert, Blair, Barlow, & Kohl, 1996; Nelson et al., 2007; Paffenbarger et al., 1986) by 22% even if practiced with a low dose (< 150 min/week) of moderate-to-vigorous intensity (Hupin

et al., 2015). However, additional benefits might be expected when the amount of PA progressively increases regarding both the intensity and the volume of exercise (Chodzko-Zajko et al., 2009). Moreover, PA effects are positively correlated with a higher level of individual fitness (Kampert et al., 1996), where the percentage of functional fitness decline (e.g. lower and upper body muscle strength, lower and upper body flexibility, aerobic endurance, and motor agility / dynamic balance) is generally consistent with age-related declines in physical performance (Rikli & Jones, 1999).

Therefore, interventions including both endurance and strength activities (Nelson et al., 2007) alone or along with dietary manipulation and / or cognitive interventions might be plausible strategies that might counteract the aforementioned negative changes and risks, making older adults' life more comfortable (Ball, Berch, & Helmers, 2002; Buchman et al., 2012; Harman, 1981; Marusic et al., 2016; Pišot et al., 2015). Accordingly, there is ample evidence suggesting that the combination of proper dieting (Fiatarone et al., 1994; Kim et al., 2012; Messier et al., 2004) and PA could show greater benefits on functional fitness than either intervention alone.

The current Recommended Dietary Allowance for the minimum protein intake for adults, including older adults population, is 0.8 g protein / kg BM / day (WHO, 2007). However, recent research results suggest that the recommended protein intake does not promote optimal health or protect older adults from age-related body changes (Morley et al., 2010; Paddon-Jones & van Loon, 2012; Volpi et al., 2003). Based on new evidence, the PROT-AGE Study Group recommends an average daily intake in the range of 1.0 to 1.2 g / kg BM / d for healthy older adults, 1.2 to 1.5 g / kg BM / d for those who have acute or chronic diseases and 2.0 g / kg BM / d for people with severe illness or injury or with recognizable malnutrition (Bauer et al., 2013).

The consumption of higher protein diet, at least 1.2 to 1.6 g / kg BM / day of high-quality protein with concentrated source of essential amino acids, including branched amino acids (BCAA) leucine, could prevent age-related sarcopenia, the loss of muscle mass and strength. Including ~30 g of protein per meal seems a successful strategy to achieve optimal health outcomes in adults (Phillips, Chevalier & Leidy, 2016).

Exercise greatly increases energy expenditure and promotes oxidation of BCAAs (Rennie, 1996). BCAAs are regulators of protein metabolism and are key metabolic precursors for glutamine and alanine synthesis (Choudry, Karinch & Souba, 2006). These properties have suggested that BCAAs may have interesting and clinically-relevant metabolic effects. The effects of BCAA supplementation before and after exercise has beneficial effects for decreasing exercise-induced muscle damage and are responsible for the direct stimulation of muscle protein synthesis and the suppression of exercise-induced protein breakdown (Coombes & McNaughton 2000; Fujita & Volpi, 2006; MacLean, Graham & Saltin, 1994; Nosaka, 2003). In addition, amino acids, particularly BCAAs, may be used clinically to attenuate diet-induced muscle atrophy (Layman, 2003) and prevent sarcopenia in older adults (Koopman et al., 2006; Volpi et al., 2003; Volpi et al., 2007).

Various cognitive training approaches revealed considerable beneficial effects in improving specifically targeted cognitive abilities (i.e. memory, reasoning and proces-

sing speed) (Ball et al., 2002; Edwards et al., 2005; Saczynski, Willis, & Schaie, 2002), with some evidence of positive transfer to non-specifically trained cognitive functions and activities of daily living (Ball et al., 2002; Marušič et al., 2016; Willis, Tennstedt, Marsiske, & et al., 2006). For example, the study by Edwards et al. (2005) provides evidence that speed processing training has the potential to enhance everyday functions that help to maintain independence and quality of life, particularly when the training is targeted toward individuals who most need it. In a five-year study, Willis et al. (2006) showed that cognitive training resulted in lower functional decline in self-reported instrumental activities of daily living, which was evident up to 5 years after the initiation of the intervention. Furthermore, a multidimensional intervention which combined diet, exercise, cognitive training and vascular risk monitoring, showed 25 % better results in cognitive functions as compared to the controls (Ngandu et al., 2015). Regarding the aforementioned positive influence of cognitive and PA interventions and their training specificity, their combined effects might have greater effects on instrumental activities of daily living or even functional fitness. Moreover, Theill et al. (2013) investigated the effects of a simultaneously performed motor-cognitive training compared to a single cognitive training and to controls. They concluded that the combined motor-cognitive training presents a promising concept to improve cognitive and motor-cognitive dual--task performance, offering greater potential on daily functioning, which usually involves the recruitment of multiple abilities and resources rather than a single one.

Thus, the effects of physical training alone or in combination with dietary interventions, as well as cognitive training, on physical and cognitive functions are well documented, while there are almost no experimental studies that directly compare the effects of these interventions or its combination between each other and / or controls. Furthermore, the aforementioned studies mainly include community-dwelling older adults where outcome measures were specific cognitive abilities and daily activities assessed by participants' self-reports and / or with only a few physical performance tests. Thus, the influences of combined interventions in healthy, independent older adults in respect to functional fitness are unknown. In addition, according to our knowledge, this type of interventional study is one of the first performed among Slovenian older adults.

Therefore, the aim of this study was to compare the effects of three different 3-month interventions on functional fitness of healthy older adults chosen among the population of independently living Slovenians. We hypothesized that all three intervention groups (physical exercise only; combined physical and cognitive exercise; combined physical exercise and diet supplement) will have significant effects on physical fitness in comparison to the control group (CG).

METHODS

Participants

After the initial screening of 195 older adults, we recruited 40 individuals of which 30 were females (69.2 ± 5.3 years) and ten males (70.6 ± 5.4 years). The participants were randomly assigned to one of three intervention groups: i) a physical exercise group (PEG), ii) a concurrent physical and cognitive exercise group (PEG+COG), iii) a physical exercise with additional branched-chain amino acids (BCAA) daily supplementation group (PEG+BCAA) or iv) in a control group (CG). The final sample of the study included nine participants in PEG (age: 68.7 ± 5.3 years, height: 165.5 ± 6.9 cm, body mass: 71.5 ± 13.7 kg), ten in PEG+COG (age: 70.6 ± 5.4 years, height: 162.3 ± 6.7 cm, body mass: 68.8 ± 15.1 kg), eleven in PEG+BCAA (age: 69.9 ± 6.8 years, height: 166.2 ± 8.1 cm, body mass: 73.2 ± 9.1 kg) and ten in CG (age: 68.9 ± 3.4 years, height: 161.8 ± 5.1 cm, body mass: 64.4 ± 8.4 kg). The participants were healthy volunteers without serious cardiovascular or musculoskeletal diseases. The inclusion criteria were: i) at least 65 years old, ii) independently living at home (i.e. performing everyday activities without mobility aids), iii) residents of the city of Ljubljana (where the measurements were performed) and iv) feeling healthy and able to walk 2 km without stopping and using walking aids. All the participants provided a written informed consent to participate in the study according to Helsinki − Tokyo Declaration. The study obtained ethical approval from the National Medical Ethics Committee of the Republic of Slovenia.

Interventions

Each intervention lasted for 12 weeks, 3 times per week (altogether 34 sessions), with individual sessions' duration of 45 to 60 minutes. Each training session was performed at the same time of the day (starting at 10 a. m.). Thus, the training sessions consisted of three parts explained in details in Table 1 (on the left side). The volume and intensity in the second (main) part of the session was controlled by the ratio of the working and resting training time. At the beginning of the intervention (weeks 1 to 3) the working time for each exercise was 20 seconds with 40 seconds rest (work / rest ratio was 1:2); from week 4 to week 8 the ratio was 1:1 (30 s : 30 s) and at the end of the intervention (from week 9 to week 12) the ratio was 2:1 favouring the working time.

PEG and PEG+BCAA intervention consisted of the same physical activity program. The participants in the PEG+BCAA group were receiving orally 10 g of BCAA supplement immediately after each training session, three times per week and at the same time on the days without training.

Table 1: Approximate duration and examples of physical and cognitive exercises and dietary supplements.

PEG	PEG + COG	PEG + BCAA
Part I (10 − 15min):		
Dynamic warm up: a combination of stepping on site or walking forward / sideways with (additional) active flexibility stretching and rhythmic exercises were used (e.g. marching with rising and lowering the arms, high knee walking, side walking with crossover steps on clapping etc.).	Physical exercises: the same as in PEG; cognitive exercises performed concurrently with physical exercises: e.g.: list of words to remember "what to bring from the supermarket": eggs, milk, cheese, butter, cream, tomatoes, bread or "which ingredients are needed for the Savory Garlic Marinated Steaks": balsamic vinegar, soy sauce, garlic, honey, olive oil, black pepper etc.	Physical exercises: the same as in PEG;
Part II (30 − 40min):		
Eight strength and power exercises (main part) based on circuit training principle for trunk, upper- and lower--body muscles (e.g. squats, lunges, calf rises, push-ups and planks on a chair, crunches and side crunches).	Physical exercises: the same as in PEG; cognitive exercises performed concurrently with physical exercises: e.g.: naming cities, starting with the last letter of the previous city: LjubljanA, AncarA, AthenS, SydneY etc.; counting backwards from 100: in a step of 1 (99, 98, 97 etc.); in a step of 17 (83, 66, 49 etc.).	Physical exercises: the same as in PEG.
Part III (10-15min):		
Flexibility and relaxation exercise, with focus on breathing technique in order to restore body functions on its initial level was used.	Physical exercises: the same as in PEG; Cognitive exercises performed concurrently with physical exercises: List all the words from the Part I.	Physical exercises: the same as in PEG.
Post exercise		
/	/	10 g BCAA

Comparing with PEG and PEG+BCAA intervention program, PEG+COG intervention consisted of similar physical exercises, while cognitive tasks were added. During the warm up exercises, each participant in PEG+COG received a list of words that he / she needed to remember and report at the end of each session, see Table 1. (mid-side). The lists of words were different for each participant and were changing each session. The main part consisted of the same physical exercises as for the PEG with additional cognitive tasks targeting on working and short-term memory, attention, mental rotation and visual-spatial perception. Examples of cognitive tasks were naming animals on a certain letter, counting backwards, listing all flavours that remind you of summer etc. while performing physical exercises. Finally, during the flexibility and relaxation exercises, the participants in PEG+COG were asked to disclose previously delivered list of words.

Participants in the CG had only pre- and post-measurement screening with no specific interventions in-between and were asked to maintain their usual daily activities.

Measurements

All groups were tested before (pre) and after (post) the interventions. On the testing day, the participants completed all Senior Fitness Test items (Rikli & Jones, 1999; 2001) in order to determine subjects' lower and upper body strength, flexibility, agility, aerobic endurance and dynamic standing balance. The Senior Fitness Test consists of six assessment items (i.e. the Chair Stand Test, Arm Curl Test, Chair Sit and Reach Test, Back Scratch Test, Timed Up and Go Test and Six-Minute Walk Test). The Chair Stand Test assesses lower body strength. Each subject completed two practice repetitions and one 30-second test trial. The recorded score was the total number of stands executed correctly within 30 seconds. The Arm Curl Test assesses upper body strength. Each subject completed two practice repetitions and one 30-second test trial sitting on a chair. Women used 2.5 kg, while men 3.5 kg barbells. The score was the total number of arm flexions and extensions through the full range of motion in 30-seconds. The Chair Sit and Reach Test assesses lower body flexibility. Each subject completed two practice trials and two test trials. The score was the longest distance achieved between the extended fingers and the tip of the toe. The Back Scratch Test assesses upper body flexibility. Each subject completed two practice trials and two test trials. The score was the shortest distance achieved between the extended middle fingers. The Timed Up and Go Test assesses agility and dynamic balance. Each subject completed one practice trial and two test trials. The score was the shortest time to rise from a seated position, walk 8 feet, turn around the cone, and return to the seated position. The Six-Minute Walk Test assesses aerobic endurance. The score was the total distance walked in six minutes around the two cones 15 m apart.

Additional to the Senior Fitness Test battery, participants also performed the Four Square Step Test / FSST (Dite & Temple, 2002) and the Grip Strength Test. The FSST involves stepping over 4 canes that are laid on the ground at 90° angles to each other

(like a "plus" sign). The canes were 90 cm in length as first described by Dite and Temple (2002). Subjects were asked to stand in 1 square facing forward with their shoes on. They then rotated clockwise around the "plus sign" by moving forward, to the right, backward, to the left. The patients then reversed their path and moved in a counterclockwise direction. The instructions were as follows: "Try to complete the sequence as fast as possible without touching the sticks. Both feet must make contact with the floor in each square. If possible, face forward during the entire sequence." (Dite & Temple, 2002). Each subject had 1 practice trial and 2 timed trials; with all subjects completing the testing within 5 minutes. If a patient touched the cane, lost his / her balance, or did not place both feet in the square, he / she was asked to repeat the trial. The best score achieved was used for further analysis. Maximal grip strength was measured bilaterally with a portable Jamar Hydraulic Hand Dynamometer (Sammons Preston, Rolyan, Bolingbrook, IL, USA). In accordance with American Society of Hand Therapy recommendations, subjects were seated with their shoulders in 0° abduction and neutral rotation, their elbows in 90° of flexion, and their forearms in neutral pronation / supination. The average of three and two maximal repetitions was used for further analysis.

Habitual dietary intake was assessed by three-day food record and the participants were asked to continue habitual diet during the study adding 10 g of BCAA each day at 11 AM.

Statistical Analysis

All data are presented as means ± standard deviations. Data were analysed using SPSS software (version 20.0). After confirming normality and homogeneity of distribution using Shapiro-Wilk and Leven test, a 1-way analysis of variance (ANOVA) was used to compare baseline values between the groups. A two-way, repeated measures ANOVA was performed to determine changes within groups over time (pre to post) and between groups. Firstly, we compared the pooled interventions group (PEG) vs. CG (2x2 repeated measure ANOVA), and also each intervention group separately vs. CG (2x4 repeated measures ANOVA). Individual group changes from pre- to post period were assessed using the Paired-sample Student's *t*-test (two-tailed). The level of significance was set at 0.05. When significant changes were confirmed, the effect size was calculated as the mean change found in a variable divided by the standard deviation at baseline of that variable; an effect size of 0.10 – 0.19 was considered very small, 0.20 – 0.49 small, 0.50 – 0.79 moderate, 0.80 – 1.19 large, 1.20 – 1.99 very large and 2.00 or greater was considered a huge effect (Sawilowsky, 2009).

RESULTS

Initially, 67 participants were randomly divided in 4 groups; however, 40 of them passed > 90 % of sessions adherence with both pre- and post-testing. A vast majority of drop-out was a consequence of holidays, trips and large daily travel distances to admit sessions. There was no injury occurrence during this study. The average adherence to interventions was more than 80 %.

The participants followed their habitual diet and the estimated dietary intake was not different between the beginning and the end of the study. The mean daily protein intake was 0.92 ± 0.3 g / kg BM / day.

There were no significant differences in pre-tests between PEG and CG, neither in all four groups nor individually. The results from the 2 x 2 repeated measures ANOVA indicated a significant main effect of time for chair stand ($F[1,38] = 17.4$; $p < .001$; $\eta^2 = .31$), the timed up and go ($F[1,38] = 8.49$; $p = .006$; $\eta^2 = .183$), and the six-minute walk ($F[1,38] = 11.46$; $p = .002$; $\eta^2 = 0.232$) tests, while the arm curl ($F[1,38] = 4.07$; $p = .051$; $\eta^2 = .090$) and the four square step test ($F[1,38] = 3.55$; $p = .067$; $\eta^2 = .085$) were near-significant. There were significant time x group interaction effects for the timed up and go ($F[1,38] = 6.93$; $p = .012$; $\eta^2 = .154$) and the four square step test ($F[1,38] = 5.76$; $p = .021$; $\eta^2 = .132$). Furthermore, in Table 2, paired sample *t*-tests indicated that participants in PEG performed better at the post-test compared to the pre-test in lower body strength, agility, dynamic standing balance, and aerobic endurance, while the CG did not improve in any test performed.

Results of the 4x2 repeated measures ANOVA confirmed main time effect for body mass ($F[3,38] = 5.06$; $p = .031$; $\eta^2 = .123$), the chair stand ($F[3,38] = 34.34$; $p < .001$; $\eta^2 = .488$), the arm curl ($F[3,38] = 7.64$; $p = .009$; $\eta^2 = .177$), the timed up and go ($F[3,38] = 23.24$; $p < .001$, $\eta^2 = .392$), the four square step ($F[3,38] = 12.0$; $p < .001$; $\eta^2 = .251$) and the 6-minute walk ($F[3,38] = 20.1$; $p < 0.001$; $\eta^2 = .359$), while the back stretch ($F[3,38] = 3.30$; $p = .078$; $\eta^2 = .084$) and the grip strength ($F[3,38] = 3.36$; $p = .075$; $\eta^2 = .085$) were near-significant. There were significant time x group interaction effects for the timed up and go ($F[3,38] = 3.36$;, $p = .029$; $\eta^2 = .219$), while in the four square test ($F[3,38] = 2.31$; $p = .093$; $\eta^2 = .161$) was almost significant.

The paired sample *t*-tests indicated that the participants in PEG improved in back stretch for 100 % ($p = .005$), the timed up and go for 8.3 % ($p = .022$), the four square step for 13 % ($p = .004$), and the 6-minute walk for 9.6 % ($p = .004$), while for the chair stand up the improvement was near-significant ($p = .052$). The PEG+COG improved in chair stand up for 26.1 % ($p = .017$), the timed up and go for 15.6 % ($p < .001$) and the four square step for 8.8 % ($p = .014$). Moreover, PEG+BCAA improved significantly in almost all functional tests performed; the chair stand up for 35.3 % ($p < .001$), the arm curl for 16.6 % ($p = .023$), timed up and go for 15.8 % ($p = .028$), the four square step for 16.6 % ($p = .043$), the 6-minute walk for 10.9 % ($p = .004$), and had lower body mass for 1.8 % ($p = .012$) at post-test (Table 3).

Table 2: Pre- to post-comparison between the pooled interventions groups (PEG) and control group (CG).

	PEG (n=30)				CG (n=10)		
Tests	Pre	Post	P (*d*)		Pre	Post	P (*d*)
Body Mass (kg)	71.1±12.5	69.8±12.1	NA (-)		64.4±8.41	64.1±12.5	NA (-)
Body Mass Index (kg/m^2)	26.17 ± 3.83	25.65 ± 3.63	NA (-)		24.64 ± 3.45	23.95 ± 4.07	NA (-)
Chair Stand Up (reps)	17.2±4.52	21.7±4.94	<0.001 (**.99**)		18.1±3.44	19.6±4.78	.110 (-)
Arm Curl (reps)	19.1±3.91	20.9±4.19	NA (-)		18.9±3.84	19.7±3.19	NA (-)
Sit and Reach (cm)	3.11±10.8	1.16±10.4	NA (-)		7.31±15.1	6.31±11.9	NA (-)
Back Stretch (cm)	-4.31±9.64	-2.91±10.7	NA (-)		.511±7.71	1.71±8.21	NA (-)
Timed Up and Go (s)	5.02±1.22	4.33±0.70	<.001 (**.57**)		4.65±0.53	4.62±0.46	.790 (-)
Grip Strength (kg)	31.8±8.84	30.9±8.87	NA (-)		30.1±4.94	29.1±4.79	NA (-)
4-square step (s)	6.66±1.93	5.81±1.34	<.001 (**.45**)		6.41±1.54	6.51±1.38	.778 (-)
6-min walk (m)	537±67.8	578±66.1	<.001 (**.61**)		595±81.8	621±75.3	.286 (-)

NA – Not Applicable as time or time x group interaction effects were not confirmed.
P – Significance level of Paired-sample t-test.
d – Effect size.

Table 3: Pre- to post-comparison between physical group (PEG), physical-cognitive group (PEG+COG), physical-dietary group (PEG+BCAA), and control group (CG).

		PEG (n=9)		PEG+COG (n=10)		PEG+BCAA (n=11)		CG (n=11)	
			P (*d*)		P (*d*)		P (*d*)		P (*d*)
Body mass (kg)	pre	71.6 ±13.7		68.8 ±15.1		73.2 ±9.17		64.4 ±8.41	
	post	69.6 ±13.5	.068 (.14)	67.7 ±13.8	.109 (-)	71.9 ±9.79	.012 (.14)	64.0 ±12.5	.831 (-)
Body Mass Index	pre	25.98 ±3.65		26.01 ±5.14		26.48 ±2.79		24.64 ±3.46	
	post	25.24 ±3.41	NA	25.61 ±4.63	NA	26.02 ±3.06	NA	23.95 ±4.07	NA
Chair stand up (reps)	pre	20.0 ±4.12		17.2 ±2.48		14.9 ±5.24		18.1 ±3.44	
	post	23.6 ±5.38	.052 (.86)	21.7 ±4.49	.017 (1.81)	20.2 ±4.89	<.001 (1.01)	19.6 ±4.78	.110 (.21)
Arm curl (reps)	pre	20.7 ±3.35		19.2 ±3.52		17.4 ±4.36		18.9 ±3.84	
	post	22.9 ±4.85	.126 (.66)	19.7 ±2.83	.740 (.14)	20.4 ±4.43	.023 (.67)	19.7 ±3.19	.235 (-)
Sit and reach (cm)	pre	9.11 ±13.12		1.60 ±9.43		-0.45 ±8.75		7.30 ±15.1	
	post	6.44 ±8.80	NA	0.90 ±12.0	NA	-2.90 ±9.13	NA	6.30 ±11.9	NA
Back stretch (cm)	pre	-3.11 ±9.14		-4.00 ±10.5		-5.55 ±9.99		0.50 ±7.70	
	post	.00 ±8.06	NA	-4.40 ±13.8	NA	-3.90 ±10.0	NA	1.70 ±8.20	NA
Timed up and go (s)	pre	4.42 ±0.24		5.17 ±0.64		5.38 ±1.85		4.65 ±0.52	
	post	4.05 ±0.40	.022 (1.48)	4.36 ±0.41	<.001 (1.26)	4.53 ±1.00	.028 (.46)	4.62 ±0.46	.790 (-)
Grip strength (kg)	pre	34.6 ±8.58		32.7 ±10.2		28.7 ±7.53		30.0 ±4.94	
	post	33.88 ±8.78	NA	32.1 ±8.22	NA	27.5 ±9.15	NA	29.1 ±4.79	NA
4 square step (s)	pre	6.23 ±1.13		6.80 ± 1.01		6.90 ±2.93		6.41 ±1.54	
	post	5.41 ±1.08	.004 (.72)	6.20 ±0.78	.014 (.59)	5.75 ±1.86	.043 (.39)	6.51 ±1.38	.778 (-)
6 min walk (m)	pre	557 ±55.3		542 ±53.6		517 ±86.6		596 ±81.8	
	post	611 ±57.0	.004 (.97)	555 ±58.8	.343 (.25)	574 ±73.6	.004 (.66)	621 ±75.4	.286 (.31)

NA – Not Applicable as time or time x group interaction effects were not confirmed.
P – Significance level of Paired-sample t-test.
d – Effect size.

DISSCUSSION

Individual intervention groups have small sample sizes, therefore, we compared cumulative effects of all three interventions, by pairing all intervention groups together and contrasting vs. the CG. Thus, the results showed significant time effects for Chair Stand Up, the Timed Up and Go, and the Six-Minute Walk tests in interventions group, while the CG did not improve in any test. Furthermore, certain meaningful interactions were seen in respect to the timed up and go as well for the four square test, suggesting that the applied physical training program influenced mostly agility and dynamic standing balance, which was expected in relation to physical intervention program design. The effects were large (the chair stand up), moderate (the timed up and go and the 6 min walk) and small (the 4 square step). When all groups were compared between each other individually, there was significant improvement observed in physical fitness tests after three months of interventions compared to the baseline in all intervention groups, except in CG, where body mass decreased only in PEG+BCAA.

Our findings are consistent with findings from the literature (Chang et al., 2004). Although we cannot compare our interventions directly regarding the training design, their results are similar with ours, which suggests that older people could benefit from various supervised physical exercise programs. However, the intensity and the volume of exercise is important as demonstrated by Cyarto et al. (2008) when comparing the effects of home-based resistance training, group-based resistance training, and group-based walking on functional ability in older adults. After 20 weeks of training with only two weekly sessions, they showed that both groups of resistance training experienced improvements in strength, lower-body flexibility, and agility / dynamic balance while there were no observed improvements in the walking group. Therefore, frequency of two sessions per week used in the aforementioned study was far below those generally suggested (i.e. 30 minutes in duration and up to five weekly sessions) in order to promote and maintain health (Nelson, et al., 2007, Haskell, et al., 2007).

Taken together, the results of some systematic reviews and meta-analysis (Cermak, de Groot, Saris, & van Loon, 2012; Cruz-Jentoft et al., 2014; Finger et al., 2015; Nowson & O'Connell, 2015) which assessed the effect of combined intervention with protein supplementation and resistance exercise on muscle mass and the function in aged population, show the inconsistency of studies to prove the effectiveness of protein supplementation. Overall, the studies show the capacity of such intervention for electing gains in fat-free mass, a limited evidence for improvement in muscle strength, but no significant improvement to increase muscle function in older adults. The variation among studies regarding the supplementation protocols, protein sources, and amounts used are making it difficult to reach firm conclusions on this question. It was proposed that older adults need higher levels of protein intake due to their lower responsiveness to the anabolic stimulus (Baum, Kim, & Wolfe, 2016). In fact, larger experiments that have demonstrated a significant functional benefit from combined intervention with resistance exercise and protein intake exceeded the range from inadequate intakes to

optimal protein intakes (≥1.2 g/kg BM/day) and lasting for few months (Chalé et al., 2012; Tieland et al., 2012).

Although protein supplementation failed to point out consistent results, new evidence shows that branched chain amino acids (BCAA), such as leucine, at a daily amount of either 2.5 g or 2.8 g in combination with resistance exercise may affect muscle protein synthesis, muscle recovery following illness, and muscle mass (Bauer et al., 2013). Katsanos et al. (2006) demonstrate that the attenuated response of muscle protein synthesis in older adults, following the ingestion of small amounts of amino acids, can be reversed by the ingestion of additional amount of leucine. These data may explain the role of BCAA, especially leucine in reversing the lack of response following the protein-based supplementation.

In our study, the PEG+BCAA group was supplemented with 10g BCAA immediately after the exercise. However, even not significantly different, this intervention group experienced greater improvements in leg strength compered to others. For example, leg strength improved most (35.3 %) in the PEG+BCAA group, while the PEG and PEG+COG groups improved less i.e. 26.1 % and 17.7 %, respectively, which is consistent with previous findings (Verdijk et al., 2009). In the study by Verdijk et al. (2009), 26 healthy older man, aged between 70 and 74 years were randomly assigned to a progressive, 12-week resistance-type exercise training program with (protein group) or without (placebo group) protein provided before and immediately after each exercise session (3 sessions per week, 20 g protein per session). Although they trained with the resistance intensity of 65 % to 75 %, both training groups showed improvements of 25 % to 30 %, similar to our results.

It is difficult to compare our results to other studies due to different exercise protocols and supplementation used. A few studies that show improvement in functional outcome in older adults included the participants who generally have an inadequate protein intake of 0.8 g / kg BM / day (Kim et al., 2012; Tieland et al., 2012). Similarly, our participants had lower dietary protein intake (0.92 g / kg BM / day) than recommended (WHO, 2007) and, therefore, may benefit from the combined intervention.

Regarding aerobic endurance, only the PEG and PEG+BCAA improved for 9.6 % and 10.9 %, respectively. Bearing in mind that the PEG+COG had a more demanding cognitive aspect of exercise rather than physical, our results suggest that more than 30 minutes of moderate intensity PA is needed to induce positive alterations in aerobic endurance in older population; and / or two exercise models should be performed separately (i.e. not combined in the same task). Furthermore, future studies should include measurements of various cognitive-motor tasks. In 375 elderly community residents, Oswald and colleagues (2006) found significant training-related effects after five years of combined interventions. In detail, they showed that when compared with a non-treatment group, both physical and cognitive status can be preserved on a higher level, as well as emotional status of involved participants (as reflected through fewer depressive symptoms). Our PEG+COG group was included in the so-called broad approach that targets multiple domains of cognitive processes, which might be more effective than a specific one that includes only a sole or limited-set targeted cognitive functions (Hol-

tzer et al., 2006). Recent studies revealed that cognitive-based protocols can positively influence mobility-related outcomes in different population of older adults, namely, community-dwelling older adults (Smith-Ray et al., 2014), patients with Parkinson's disease (Milman et al., 2014) and older adults during a prolonged bed rest (Marusic et al., 2015; Marusic et al., in press). Therefore, we can further speculate that lack of improvements in the PEG+COG group could also originate from inadequate measurement tests which were not sensitive enough to detect cognitive-motor related improvements.

CONCLUSION

Our research findings indicate that physical activity, alone or combined with cognitive and nutritional interventions could enhance functional fitness in older adults. More than 30 minutes of moderate-intensity physical activity, three times per week is needed for an improvement in aerobic endurance, while same volume of specific training program is enough to induce positive alterations in dynamic balance and agility. Thus, when nutritional supplementation is added to physical exercise, results regarding functional strength task and body mass were more pronounced.

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HEALTHY AGEING AT HOME: ERGONOMIC ADAPTATIONS OF INTERIOR DESIGN AND SELF-ASSESSED QUALITY OF LIFE OF OLDER ADULTS OF THE MUNICIPALITY OF LJUBLJANA

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ABSTRACT

Population is ageing and many nations already respond by developing and promoting special strategies of healthy ageing. Living environment is one of the factors that can contribute to healthy and safe ageing at home, providing that it is well adapted to the needs of older adults. On the contrary, it can cause stress, discomfort and lead to injuries, resulting in the loss of independence and autonomy. With the use of a questionnaire, conducting a survey and an analysis regarding the adaptability of living environment to the needs of older adults, we obtained an insight into the quality of living environment of the elderly. In the Quality of Life Survey as a part of the A-Qu-A questionnaire, the participants were 198 older adults with an average age of 71.5 ± 5.2 years of age. Further on, 83 of them participated in the study of the "Adaptation of the Living Environment to the Needs of Older People," carried out in the homes of the participants, (with an average of 76 ± 1.2 years of age). The results showed that there is a significant difference between the subjective evaluation of the participants and the evaluation by the professionals regarding the estimation of appropriate lighting. The participants who estimated their quality of life as better are more likely to have sufficient or adequate lighting and more adaptations in the kitchen, which makes daily kitchen work easy and safe. Further investigation dealt with the ergonomic adaptation of the bathrooms, where we found out that less than 15 % of the participants installed

the handrails in the shower or bath tub, which can significantly contribute to safety. Additionally, physical capability as part of quality of life negatively correlates with the number of adaptations made in bathroom (r = -0.149; p = 0.039), which refers to the fact that the adaptation of accessories (handrails) were only installed when the need for them appeared. With minor changes in the living environment and taking care for maintaining psycho-physical capabilities, older adults can easily and safely perform everyday tasks, which prolongs an individual's autonomy and independence − the fact we are still not sufficiently aware of.

Keywords: *older adults, ergonomic furniture adaptation, self-assessed quality of life.*

ZDRAVO STARANJE NA DOMU: ERGONOMSKA PRILAGODITEV NOTRANJE OPREME IN SAMOZAZNANA OCENA KAKOVOSTI ŽIVLJENJA NA PRIMERU STAREJŠIH ODRASLIH V MESTNI OBČINI LJUBLJANA

IZVLEČEK

Človeštvo se stara in mnoge države so se na to dejstvo že odzvale z razvijanjem in promocijo ukrepov za zdravo staranje. Bivalno okolje je eden od dejavnikov, ki lahko prispevajo k zdravemu, predvsem pa k varnemu staranju na domu, če je le to urejeno in prilagojeno potrebam, ki jih imajo starejši odrasli. V nasprotnem primeru lahko neprilagojeno bivalno okolje povzroča stres, slabo počutje in izgubo samostojnosti, poleg tega pa je lahko tudi vzrok za poškodbe. V raziskavi o kvaliteti življenja je sodelovalo 198 starejših odraslih s povprečno starostjo 71 ± 5,2 let. Nadalje se je 83 izmed vseh udeležilo tudi raziskave "Prilagojenost bivalnega okolja potrebam starejših oseb", ki se je izvajala na domovih uporabnikov (povprečna starost 76 ± 1,2 leti). Študijo smo izvedli z uporabo dveh prilagojenih vprašalnikov ter osebnim vpogledom v bivanjski prostor udeležencev. Ugotavljamo, da glede na priporočila obstajajo pomembne razlike med oceno primerne osvetlitve po mnenju starostnikov v primerjavi s strokovno oceno izmerjeno na domu. Starostniki, ki so imeli primerno urejeno osvetljenost prostorov, so kvaliteto svojega življenja ocenjevali višje in so poročali tudi v več primerih prilagoditev v kuhinji, ki olajša dnevno delo v kuhinji. Nadalje smo raziskali stanje ergonomske prilagojenosti kopalnic udeležencev, kjer smo ugotovili, da je manj kot 15 % sodelujočih v raziskavi že uredilo ustrezne ročke za oporo v kopalnici pod tušem ali v kopalni kadi. Telesna zmogljivost teh posameznikov, kot komponenta kvalitete življenja, statistično značilno negativno korelira s številom prilagoditev v kopalnici (r = -0,149; p = 0,039). Ti svojo telesno zmogljivost kot del kvalitete življenja ocenjujejo

nižje. To vodi do ugotovitve, da prilagoditve bivalnega prostora starostniki uredijo šele, ko jih potrebujejo. Z manjšimi prilagoditvami v bivalnem okolju ter z ohranjanjem psiho-fizične zmogljivosti bi starejši odrasli lahko vsakdanja opravila izvajali lažje, z manj napora in bolj varno. To bi pomenilo daljše samostojno in neodvisno bivanje starejših odraslih v domačem okolju - dejstvo, ki se ga ne zavedamo dovolj.

Ključne besede: *starejši odrasli, ergonomija, prilagoditev pohištva in opreme, samoocena kakovosti življenja.*

INTRODUCTION

Being aware of the fact that population is ageing, the main focus and challenge for nations are how to increase or at least maintain the quality and years of healthy life (Drewnowski et al., 2003; WHO, 2002). Many nations have already responded by developing and implementing the policies to promote healthy ageing. According to the last data from 2011, in Slovenia the older adults (65 +) represented 16.6 % of population (women 19.8 %, men 13.3 %). EROPOP2010 Eurostat projection expects that lifespan will be prolonged, so older adults (65 +) will represent 27.5 % of population in 2040, yet in the year 2050, 30.6 % of population and in the year 2060 every third Slovenian will be older than 65 years of age (Statistic Office RS, 2012).

A lot of older citizens live in homes that are not properly adapted to the needs of older adults (Colombo, Vitali, Molla, Gioia, & Milani, 1998), which can cause stress, discomfort and loss of independence. In the last decade, there has been a trend in developed countries to provide independent living conditions for older people, in a familiar home environment and for as long as possible (Grdiša, 2010). In Slovenia, only 7.85 % of people aged 65 and over live in the old people's homes, therefore, it is very important that housing and equipment for older adults and disabled persons is facilitated and adapted to the safety and comfort of their use (Hvalič Touzery, 2009). The research performed by the School of Architecture, University of Sheffield, UK (2004), regarding the impact of architecture on the quality of life, with the emphasis on environmental suitability of housing for the elderly, found out that the design of buildings have both positive and negative effects on the quality of residents' life. That is particularly important since older people spend most of their time in the building in which they reside. Due to the increased susceptibility of older adults to infections and diseases, they found that the compliance with hygiene standards is of extreme importance, particularly in the parts of buildings where food preparation and dining take place (Torrington, Barnes, McKee, Morgan, & Tregenza, 2004). In the research by Colombo et al. (1998), the most frequent problems faced by older adults were identified. Among other things, older adults reported a safety problem in the kitchen (as many as 33 % of the dwellers) and of inadequate lighting (25 % of the dwellers). Very few older adults can afford a thorough home adaptation because of financial reasons. It was found that 60 % of older

people live in homes that have not been renovated or ergonomically adopted or newly equipped more than 20 years, which affects lower comfort and safety of the residents. More than 14 % of older people in England live in inadequate housing condition at home that urgently needs adaptation (Boyo, 2001).

In addition, only 10 % of older adults decide to modify the existing equipment and adjust them to new needs (Gilderbloom & Markham, 1996). The studies mainly focused on furniture design for seniors, which is extremely important as most products include the elements designed for young people, so that older adults often have difficulties in using them (Fabisiak & Jankowska, 2016; Klos, Fabisiak, & Kaczmarek, 2014). It should be emphasized that the designers and furniture manufacturers who wish to create products tailored to the needs of elderly people should first identify and focus on the needs arising from the old-age-related changes occurring in the human body (Fabisiak & Klos, 2016). However, there is also evidence that older adults have poor knowledge of the possible psycho-physical changes in the old age and about positive effect on performance of daily routines and, thereby, the possibilities to prolong the period of independence in home environment (Batič et al., 2016).

Beside the adaptation of living environment to age-related changes in functionality of older adults, we were focused also on the potentially dangerous places in the apartment. Evidence showed that most accidents in the home environment happened in the kitchen and bathroom (Stevens, 2005), so we need to pay more attention to the ergonomics of the furniture to maintain the performance of daily habits easy and, most of all, safe.

In addition, the lighting proves to be a common problem with the kitchen equipment. The kitchen is a workspace where we use sharp knives, home appliance and hot dishes, so it is necessary that the entire kitchen, especially the working area has proper lighting. A particular attention should be paid to the main working surface, sink and cooker hob area. When installing the lighting and choosing a single lamp, we must pay attention to disturbing shadows, glare and adequate power. For lighting which is directed towards the workplace, it is necessary to be installed from the front or from the left side and not from behind. This prevents the appearance of throwing shadows on the worktop.

Another potentially dangerous place in the living environment is the bathroom (Carter, Campbell, Sanson-Fisher, & Redman, 1997). The handrails intended for greater security should be placed at the appropriate level and at appropriate places. Our next analyses were directed to the research of handrails and other accessories (shelves, anti-slip mats) and their connection with the self-assessed quality of life, as well as the falls that occurred in a one year period.

Within the definition of healthy ageing (Pell, McClure, & Bartlett, 2005) as *"a lifelong process optimizing opportunities for improving and preserving health and physical, social and mental wellness; independence; quality of life and enhancing successful life-course transitions"* we were focused on the situation of living old people's environment. Having in mind the self-assessed quality of life according to the status of ergonomics adapted in living environment and furniture, we wanted to

examine the effect on independence and diminishing the potential injuries. That is why we examined the current status of adapted living environment when prolonging autonomy and ensuring the independence of older adults, their safety and comfort when living at home.

According to the presented facts, the research questions we considered in this part of the project were the following: i.) what is the present state of ergonomic interior design of old people's home environment in the studied sample of older population in the Municipality of Ljubljana and ii.) does the self-assessed quality of life of older adults correlate with the level of adapted living environment (considering the number of adaptations).

METHODS

The study was a part of the project titled A-Qu-A: Active and Quality Ageing, (Project no. 4300-472/2014), supported by Norway Grants. The leading partner of the project was the Ljubljana Home Care Institution, Department of Home Care Ljubljana (Slovenia), while the research partners of the project were the Institute for Kinesiology Research, Science and Research Centre, University of Primorska and the Faculty of Design that collected all the data of the mass measurements and carried out the intervention. Through a complex questionnaire and with an interview we tried to determine the status of interior adaptations to the needs of older adults living in dwellings within the Municipality of Ljubljana. The research protocol was conducted according to the *Declaration of Helsinki*, all the participants also signed a written consent to participate in the measurements.

Participants

In the Quality of Life Survey, there were 198 older adult participants (151 female, 70.35 ± 5.8 years of age and 47 male, 71.54 ± 5.3 years of age). 83 of them (58 female and 25 male), with their average age of 76 ±1.2 years, have additionally decided to participate also in the second Survey – "Adaptation of the Living Space to the Needs of the Elderly." All the participants of the study are the residents of the Municipality of Ljubljana.

Measurements

In the Quality of Life Survey, 198 older adults filled out a complex A-Qu-A questionnaire regarding the demographic and socio-economic data, healthy lifestyle, nutrition habits and ergonomic adaptation of interior design and furniture. They were all initially tested for physical characteristics, functional capabilities and general health status.

AQuA questionnaire was a combination of different parts of standardized questionnaires (GPAQ, QOL), where part of QOL was used also in the survey of Quality of Life of National Institute for public health. It consisted of 78 questions and was sent to each participant who agreed with a signed consent to participate in the mass measurement. The participant brought their own questionnaire, filled out on the first day of measurement. After the measurement, the researchers checked the understanding and the missing answers together with the participants, to obtain more relevant data. In the second survey titled "Adapt the Living Space to the Needs of the Elderly," the questionnaire was filled out by a group of interior design experts during their visit at the participant's home. The questionnaire was divided into 7 groups according to individual residential premises and comprised a total of 121 questions. Most of the questions were related to individual elements that affect the increased security and functionality processes in homes for the elderly. The adequacy of light exposure was measured using the LUX--meter (CEM, model DT-1301).

Statistical Analysis

All data were organized in Microsoft Excel and analyzed in IBM SPSS Statistical Package, Version 20.0. Descriptive statistics, independent samples of T-test for gender difference, the number of adaptations and Spearman test for correlation between the number of living environment adaptations and quality of life (general health, physical capability, psychical condition and general quality of life) were used. P values $< .05$ were considered significant.

RESULTS

During the visit at the participant's home, we found out that only 22 % of the total of 83 respondents have appropriate task lighting. The measurements for determining the suitability was performed using the LUX meter. There is a high level of those who assessed their kitchen lighting inadequate (Figure 1).

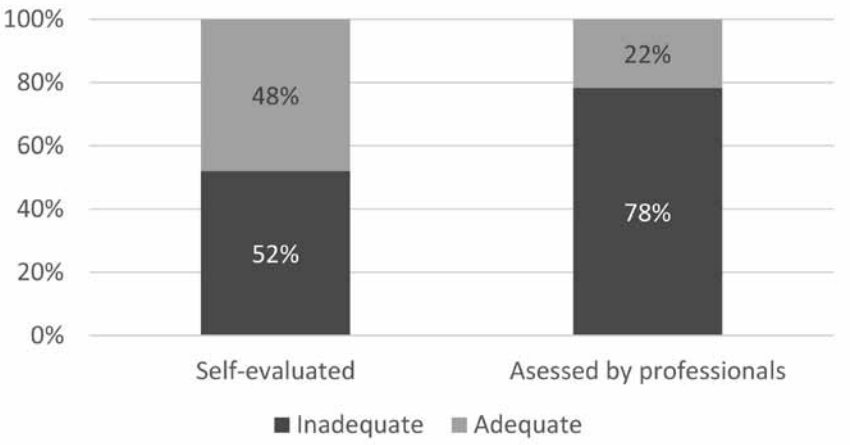

Figure 1: Comparison of adequate or inadequate lighting of working area by professional assessment criteria and self-assessed criteria.

Additionally, we have analyzed the bathroom's equipment for safety when entering into a bath tub (a step) and the shower equipment (a chair) and additional accessories such as handrails, shelves for shampoo and anti-slip mats. The results showed that 59 % of the participants have a shower and only 33 % participants reported a bath with at least one of the listed accessories (Figure 2 and Figure 3 respectively). The other 8 % did not report any ergonomic accessories. The results from the questionnaire showed that only less than 15 % of the respondents installed the handrails in the shower or either in the bath tub, which significantly increases safety when using the bathroom. From the interviews, it was evident that persons who have handrails installed were already receiving benefits by physiotherapists or occupational therapists who advised them to set up such holders. Similar results were found also with the presence of a seat / a chair in the shower.

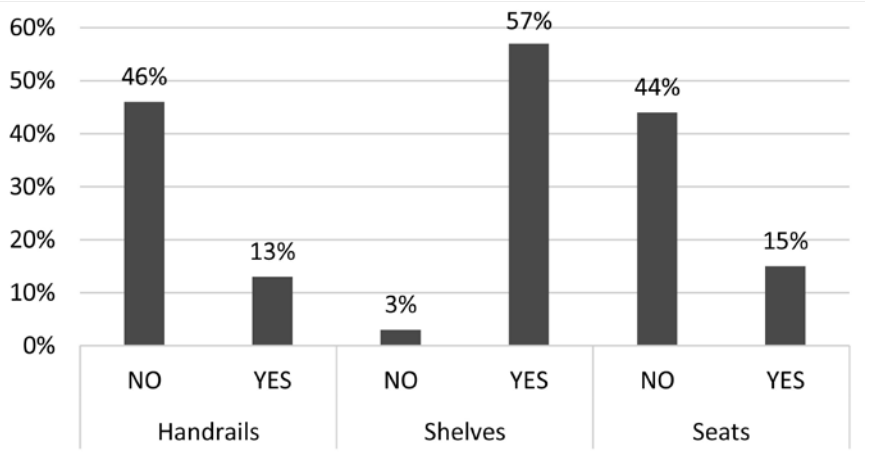

Figure 2: Number of the participants who have equipment in the shower (n = 117).

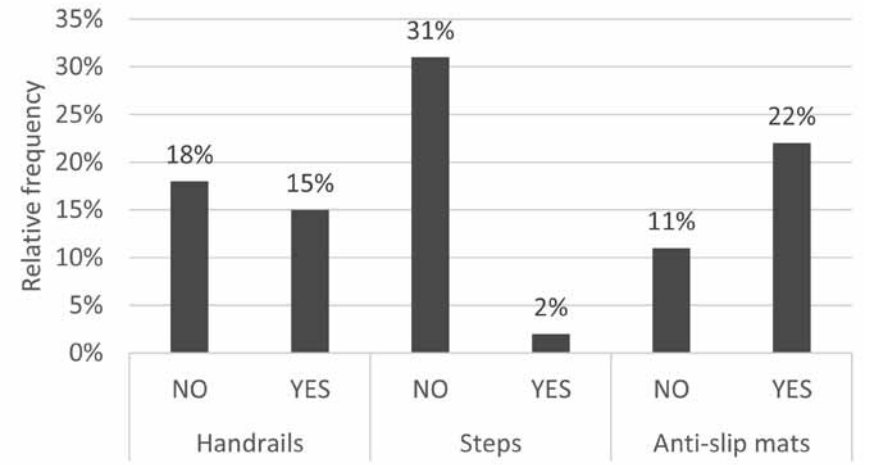

Figure 3: Number of the participants who have specially adapted equipment in the bath tub (n = 66).

Within the study, we additionally analyzed the self-assessed adequate living environment (no. of adaptations) and its correlation according to the self-assessed "Quality of Life": general health, physical capability, psychological conditions and general quality of life. The participants assessed the quality of life on the qualitative scale, in the range

from 1 − ”very bad,” 2 − “bad,” 3 − “fair,” 4 − “good,” and 5 − ”very good.” In the correlation analysis also the variables such as “education level” and “number of falls in the previous year” were included. Since bathroom is marked as a place with the highest rate of accidents, we have gathered the data of the number of participants’ adaptations of useful accessories such as handrails, shelves and seats in the shower or steps, shelves and anti-slip mats in the bath tubs, which could prevent potential falls and slips.

The number of adaptations showed us logical results in negative correlation (ρ = -.149) between the number of adaptations in the bathroom and the self-assessed physical capability, which could be argued that older adults who assessed their physical capability lower have more adaptations than those with better physical capability. Additionally, we found no correlation between the number of the adaptations with the presented variables (Table 1) and other life quality determinants. Also, there is no gender difference referring to the number of adaptations among men and women who participated in project.

Table 1: Spearman correlation of adaptations in the bathroom and Quality of Life.

Spearman's rho		**General health status**	**Physical capability**	**General Quality of Life**
No. of Adaptations in in the bathroom	Correlation Coefficient	-.036	-.149*	-.089
	Sig. (2-tailed)	.620	.039	.213
	N	197	192	198

Spearman's rho		**Psychological status**	**Level of education**	**No. of falls last year**
No. of Adaptations in in the bathroom	Correlation Coefficient	-.084	-.078	-.021
	Sig. (2-tailed)	.241	.272	.767
	N	198	198	197

Correlations were found between the characteristics of QOL, especially physical status, which were estimated better by those participants who assessed general health (ρ=.490), physical capability (ρ=.339) and general quality of life (ρ=.731), which is reasonable, and also we can confirm that those with higher education level more likely estimate psychological status (ρ=.282) and general quality of life (ρ=.246) better than those with lower. On the other hand, the variable “number of falls last year” showed us significant negative correlations regarding general health (ρ= -.260), physical capa-

bility (ρ=-.213) and education (ρ=-.148), which can be argued that older adults who are less healthy have lower physical capabilities and lower educational level are more likely to fall in the previous year.

Additionally, we can find a larger share of those with the self-assessed quality of life as "very good" and "good" and reported more adaptations in the kitchen which simplify their daily kitchen work and provide safety (automatic shutdown of the oven; lower edge of the oven at the height of the kitchen countertop and easy cleaning of the kitchen hob), which could suggest possible correlation between QOL and adaptation of furniture (Figure 4).

Figure 4: Self assessed General Quality of Life in relation to the characteristics of kitchen adaptation.

Still, a significant number of participants do not pay enough attention to the safety in the bathroom, whereas only 18 % possess the handrails, 31 % have a seat in their shower and 22 % have an anti-slip mat. For this reason, the warnings of possible accidents in the bathroom (falls, slips) should be much more highlighted. Living in unadapted apartments does not allow an independent life and could even present a danger for health.

DISCUSSION

Within the detailed analysis of ergonomic characteristics of participant's homes, we focus on two main characteristics: adequate lighting in the kitchen work area and the safety of equipment and accessories in the bathrooms. For adequate lighting, 1400 lux or more for work surface and 600 lux or more for general lighting are advised. However, a general recommendation is that the lighting of between 1400 and 2000 lux is advisable for the working surface and from 600 to 900 lux for the general lighting of kitchens for people over 65 years of age (Podlesnik, 2011). Most of the participants had too weak lighting. Our findings varied from the data in the questionnaire, where the respondents self-reported having adequate worktop lighting in their kitchen with a rather higher percentage (46 %). The results indicate that older people generally think they have sufficient lighting of their work surface, but in reality the lighting in most cases is too weak, which hinders older adults at their work and may also be a cause of accidents.

Due to the fact that older adults find it difficult to stand up for a long time, in particular while they wash their hair with their arms raised, it is recommended that a seat is placed in their shower. There are special self-supporting chairs which could even be attached to the wall. Thus, older adults can sit while showering and washing their hair without any danger to slide on the slippery floor or to fall as they might get dizzy as well. The above presented results show that only 15 % of the participants have a seat placed in their shower despite the fact that many older people have problems with balance because of poorer movement skills. To enhance the security in the shower, shelves for storing soaps and shampoos also help as deposing and bending can cause a loss of balance and lead to a fall. Here we found more promising results because almost 60 % of the participants reported having a shelf for storing cosmetics in the shower. Installing the storage shelves in the shower is simple, as they can also be fixed with the help of a vacuum; that is why a majority of the respondents have shelves in the shower, however, 43 % of showers are still without shelves. Tinetti (2003) and Tomšič & Gunčar, (2012) found out that the falls of older adults grow constantly and linearly with the increasing number of risk factors among which we also rank unadjusted living environment. That could be argued that adaptation and installing the accessories (handrails) only take place after the first fall.

Older adults are not aware enough of the potential problems encountered in their own homes, and of the existing possibilities in order to create living environment with minimal interventions that could significantly ease their living at home (Hrovatin, 2015). Older adults are often afraid of any kind of adaptation, on one hand due to the fear of high costs and on the other hand due to the fear of the organization. The fact is that even a minor adaptation, which is neither financial nor organizational problem, brings significant changes that ensure greater safety and consequently prolong an individual's independence.

With this research, we found that most of older adults from our sample do not have ergonomically adopted interior design of their home, i.e. that they live in the apartments which do not suit their actual needs. Despite the fact that there are negative correlations

between self-assessed physical capability as one characteristic of quality of life and the adaptations of equipment or accessories in the bathrooms, such as holders, shelves, steps and seats, we found that higher-assessed quality of life is more common for people with higher education. That corresponds also to higher economic status and, thus, higher standards of living conditions.

CONCLUSION

According to the research, we found that the majority of older adults in our sample live in the apartments which could prove a threat to their health and prevent successful ageing. Older adults are mostly not aware enough that they could achieve a significant level of safety and independence in their living environment with only minimal interventions or adaptations. The best time to make adjustments to achieve ergonomic interior design is immediately after the retirement, when the problems are not yet present, to avoid the fact that maladjusted interior design leads to the early loss of independence. For the safe, high-quality and independent living in particular homes, it is also very important to maintain the physical and mental fitness of older adults. The need for safe, high-quality and independent living is evident so the awareness of possible small adaptations needs to be highlighted. Being aware that inadequate living environment remains a problem among older population, we need to investigate and identify the proper strategies to ensure healthy ageing with prolonged living at home. Conscious of the potential barriers to achieve adaptation in the old people's living environment should present a further challenge in creating national strategies of health promotion for the older population. As mentioned, older adults should be aware that even minor changes in their living environment could allow them to perform everyday tasks faster, with less effort and more security, but above all, that this can prolong their autonomy and independence and contribute to the sufficient quality of life even in their »golden age.«

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VERTICAL JUMP HEIGHT IN YOUNG CHILDREN − A LONGITUDINAL STUDY IN 4- TO 6-YEAR-OLD CHILDREN

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ABSTRACT

Preschool children are intensively involved in the process of developing fundamental movement skills such as walking, running, jumping, climbing, crawling and other simple movements. We aimed to compare age- and gender- related trends in countermovement vertical jump (CMJ) performance (jumping height) measured with a means of ground force plate during a longitudinal study of 4- to 6-year old children (N=79; 43% boys). Furthermore, we classified children CMJ arm-leg coordination into poor, average, or excellent on the grounds of high speed video footage. We found that CMJ height progresses significantly with age when arms are used (P<.001; η^2=.632) and without the use of arms (P<.001; η^2=.620). There were no sex effects. After classification of CMJ arm − leg coordination we found that children with excellent CMJ coordination progress more intensively than those with average coordination, whereas poorly coordinated jumpers do not progress at all. After extrapolating our data with the data of others we found logarithmic CMJ height trends until the age of 16 in both sexes, athlete boys jumping higher than the non-athletes after the ages of 14 or 15. It seems that the initial movement patterns level, in this case the observed jumping technic, develops and refines in 4- to 6-year old children at that age. We conclude that jumping coordination is a very important factor of CMJ performance in the studied age span.

Keywords*: countermovement jump; ground force plate; coordination, explosive power, pre-school children.*

RAZVOJ NAVPIČNEGA SKOKA OTROK - LONGITUDINALNA ŠTUDIJA 4- DO 6-LETNIH OTROK

IZVLEČEK

Predšolski otroci so intenzivno vključeni v proces razvoja elementarnih gibalnih vzorcev, kot so hoja, tek, skok, plezanje, plazenje in drugih enostavnih gibanj. Naš namen je longitudinalno primerjati uspešnost skoka z nasprotnim gibanjem - CMJ (višina skoka) merjeno s tenziometrijsko ploščo 4 do 6 let starih otrok (N=79; 43% dečkov) glede na starost in spol. Poleg tega smo otroke razvrstili glede na CMJ koordinacijo med rokami in nogami v slabše, povprečne ali odlične na podlagi visokofrekvenčnih video bočnih posnetkov. Ugotovili smo, da CMJ višina narašča z leti, pri skokih z uporabo rok (P<,001; η^2=,632) in brez uporabe rok (P<,001; η^2=,620). Med spoloma ni bilo razlik. Po klasifikaciji koordinacije CMJ smo ugotovili, da otroci z odlično koordinacijo CMJ napredujejo intenzivneje kot tisti s povprečno koordinacijo CMJ, medtem ko otroci s slabšo koordinacijo CMJ sploh niso napredovali. Po ekstrapolaciji naših podatkov z drugimi, smo ugotovili logaritemski trend višine CMJ do starosti 16 let pri obeh spolih, kjer po starosti 14-15 let fantje športniki skočijo višje kot fantje, ki niso športniki. Ugotavljamo intenziven trend razvoja CMJ v tem starostnem obdobju, kjer je koordinacija CMJ zelo pomemben dejavnik uspešnosti izvedbe CMJ.

***Ključne besede**: skok z nasprotnim gibanjem, tenziometrijska plošča, koordinacija, eksplozivna moč, predšolski otroci*

INTRODUCTION

The reported children sedentary behavior (Carson, LeBlanc, Moreau, & Tremblay, 2013; Colley et al. 2011; ParticipACTION 2015, 2016) and obesity (Gotay et al. 2013; Ng et al. 2014) are among the major health problems. The epidemic of physical inactivity and the associated epidemic of obesity are being driven by multiple factors: societal, technologic, industrial, commercial, financial (Council on Sports Medicine and Fitness and Council on School Health, 2006). Obesity among children in Slovenia is increasing. The data collected in the context of the European initiative show that the Slovenian children are among the most endangered of obesity among the EU countries (OECD/EU, 2016). This global trend of prolonged sitting and obesity is likely to continue due to the growing availability and popularity of computer, mobile phones, video games and television (Lepp, Barkley, Sanders, Rebold, and Gates, 2013; Public Health England, 2013) and due to less favorable food availability (Raychaudhuri & Sanyal 2012; Skidmore & Yarnell, 2004). Moreover, we must be aware that health behaviors and obesity is transferred into adulthood.

On the other hand, physical activity and exercise helps preventing chronic diseases such as cardiovascular disease (Kruk, 2007; Warburton, Nicol, & Bredin, 2006), diabetes (Kruk, 2007; Warburton, Nicol, & Bredin, 2006), cancer (Kruk, 2007; Warburton, Nicol, & Bredin, 2006), hypertension, obesity (Kruk, 2007; Warburton, Nicol, & Bredin, 2006), osteoporosis (Kruk, 2007; Warburton, Nicol, & Bredin, 2006), fall-related injuries (Kruk, 2007), depression (Kruk, 2007; Warburton, Nicol, & Bredin, 2006) and emotional stress (Kruk, 2007). Therefore, it is essential to encourage preschool children to engage healthy lifestyle as early as possible, to develop motor abilities satisfactory and develop fundamental movement skill (FMS) such as walking, running, jumping, crawling, climbing, hopping, catching, kicking, throwing and hitting a ball. If sufficiently developed, FMS plays an important role in establishing physical confidence and competence (Gallahue and Ozmun, 1998).

FMS development has been classified into stages, progressing from a beginner level to a mature level (Hynes-Dusel, 2002). The beginner level generally depicts the minimal standard of children ages 4 to 7 (Gabbard, 1992). By the completed age of 8, with practice and maturity, most children will have achieved mature level (Gabbard, 1992). The experts believe that motor delays negatively influence future motor and cognitive development (Gallahue, 1996). Therefore, mastering FMS is linked also to cognitive development (Diamond, 2000; Krombholz, 1997).

Most of the studies reports FMS data obtained in adult male subjects (Laffaye and Choukou, 2010; Harman, Rosenstein, Frykman, & Rosenstein,1990; Marković, Dizdar, Jukić, & Cardinale, 2004; Marković, 2007; Runge, Rittweger, Russo, Schiessl, & Felsenberg, 2004) and there are few longitudinal data about children development trends of both sexes where the most frequent FMSs observed are walking and the vertical jump (Focke et al., 2013). Different researchers defined the factors affecting vertical jump ability: a) composition of skeletal muscles (Kaneko, Fuchimoto, Toji, & Suei, 1983; Wilson, Newton, Murphy, & Humphries, 1993), b) well-developed alactic or anaerobic power capacity (in comparison with the athletes with high aerobic power capacity) (Shorten, 1987; Conlee, McGown, Fisher, Dalsky, & Robinson, 1982), c) neural adaptation (motor unit activation, motor unit synchronization and the specificity of the movement pattern (Wilson et al., 1993; Sale, 1988), d) initial levels of strength of the person and the ability to make use of a stretch shortening cycle (Adams, O'Shea, O'Shea, & Climstein, 1992; Duke & BenEliayhu, 1992; Wilson, Newton, Murphy, & Humphries, 1993), e) the use of elastic and contractile energy for producing dynamic muscle contractions (Adams et al., 1992; Duke & BenEliayhu, 1992), f) effective use of the arms for increased vertical velocity (Harman et al., 1990), g) trunk extension, head movements and utilization of a countermovement to initiate the stretch shortening cycle (Young, 1995; Van Soest, Roebroeck, Bobbert, Huijing, & van Ingen Schenau, 1985; Harman et al., 1990), h) upper body and abdominal (trunk) strength has also shown to be a contributing factor to vertical jump performance (Shorten, 1987; Cisar & Corbelli, 1989; Bobbert & Van Soest, 1994), and i) development of a motor pattern for vertical jump − arm swing (Young, 1995). All the above-mentioned factors develop through childhood and, thus, this development must affect vertical jump development as well as other FMS.

There have been numerous studies which have investigated jumping in adult athletes from various sports, and the most commonly reported parameter is jumping height. However, it is difficult to compare the results of various studies as they all vary greatly in the experimental design, in the duration of research, in the testing procedures utilized and in the application of training techniques. Although vertical jumping is often used in physical performance tests for both children and adults, normative data for children are lacking in the literature. Only few studies focused on jumping performance in primary and secondary school children (Klausen, Schibye, & Rasnussen, 1989; Temfemo, Hugues, Chardon, Mandengue, & Ahmaidi, 2009; Focke et al., 2013) and some in pre-school children (Neelly & Zebas, 2003; Harrison & Moroney, 2007; Focke et al., 2013). Neelly and Zebas (2003) where a research was performed on a 4.5 year-old children, while Focke et al. (2013) measured 1835 children aged from 4 to 17 years of age. They specified that boys jump higher than girls and reported cross-sectional developmental trends for both sexes.

Therefore, we aimed to develop longitudinal CMJ height trends in 4- to 6 year-old children for both sexes. Additionally, our goal is to detect the jumping technique used by children. When comparing CMJ height in children classified with different jumping coordination score (1 − poor; 2 − average; 3 − excellent) we hypothesized that the percentage of excellent jumpers would increase and excellent jumpers would progress in CMJ height more intensively with their age. We also plan to extrapolate CMJ height age trends with the data of others.

METHODS

Participants

Four-year-old children were recruited in 2009 from three randomly selected Slovenian kindergartens, all in the Coastal region: Koper, Škofije and Semedela. All tests and procedures were explained to the parents on organized meetings in kindergartens prior to the obtainment of their written consent. None of the children had any history of neuromuscular disorders or muscle diseases. In regard to the recruitment process, 160 children in total were selected (only those who had their 4th birthday in 2009), of which 79 children (34 boys, 45 girls) completed all three longitudinal jumping measurements and were selected for the analysis. Moreover, all procedures conformed to the 1964 Declaration of Helsinki and were approved by the National Medical Ethics Committee of the Republic of Slovenia.

Procedures

The organizational settings of the conducted longitudinal study were the same for all three assessments. The assessments were conducted in autumn of 2009, 2010, and

2011. A week before the assessment we notified the teachers to follow a specific protocol prior to the measurement, namely, that all major physical or sport activities were discouraged two days before the assessment. Daily, from 2 to 5 children arrived in the laboratory and performed a series of tests (body composition, muscle architecture, posture analysis, and five FMS analysis) from where only basic anthropometrical data and vertical jumping is presented in this report.

Measurements of Anthropometrical Characteristics

All children had their standing height and weight measured. Participants' body mass and height were measured by a means of standard tools. Their body mass was measured to an accuracy of .1 kilograms, while the body height was measured to an accuracy of .5 centimeters. All participants were barefoot and wearing their sportswear during the measurements. The body composition was measured with bioimpedance (BioScan 916s, Maltron, UK), where children lied on a bed for 30 minutes before the assessment.

Countermovement Jumping Height Assessment

Each child performed a 15 minutes of standardized warm-up before the FMS assessment. After the walking and running analysis we analysed jumping performance. The instruction was to jump as high as possible, using their arms and countermovement jumping (CMJ) technique. Each child performed between 3 and 5 trial jumps followed by three maximal CMJs with the use of their arms and three maximal jumps without the use of their arms on a ground force plate system (AMTI sampling at 1000 Hz.). They were also simultaneously videotaped with high-frequency camera (Fujifilm Finepix HS10) for qualitative analysis of arm-leg coordination and synchronization of movement. During each jump, there was at least one minute of rest. CMJ height was calculated based on the flight time. The highest jumps from both techniques (with and without the use of the arms) were taken for further analysis. We used several motivational methods to achieve a maximal performance (wall stickers), similarly as in some previous studies where they used balloons (Clark, Phillips, & Petersen, 1989; Jensen, Phillips, & Clark, 1994).

Countermovement Jumping Coordination Assessment

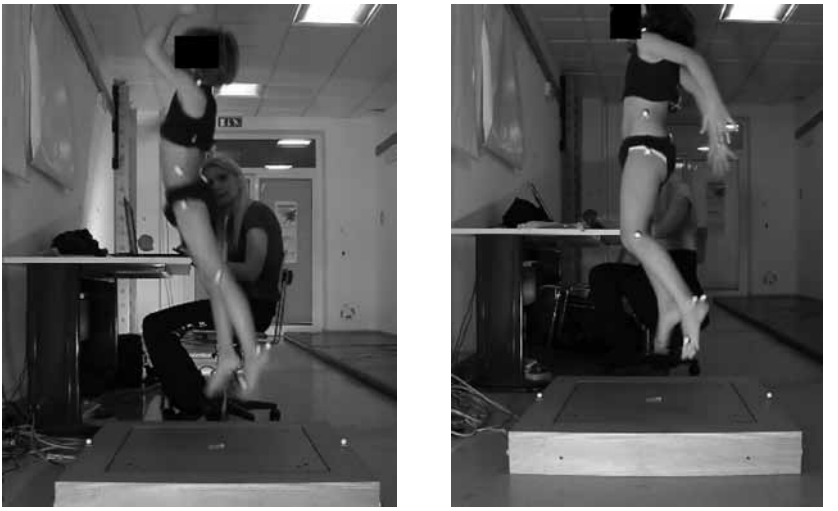
For the jumping coordination assessment, we used a scale developed by Plevnik (2014) adapted from the technique for the evaluation of the implementation of motor tasks (Vies, Kroes & Feron, 2004), where jumping coordination was qualitatively (based on high-speed video footage, see Figure 1) classified as:

POOR (score 1): Hands do not follow the body movement. They move backwards, or not at all.

AVERAGE (score 2): Hands are somewhat included in jumping performance, but less intensively or with less amplitude.

EXCELLENT (score 3): Hands follow the vertical jump in all phases, correct timing, intensity and amplitude.

Figure 1: Coordinated vertical jump classified as excellent (left) and non-coordinated vertical jump classified as poor (right).



Data Analysis

The data were analyzed using SPSS (version 22, IBM, USA) and Microsoft Excel (version 2013, Microsoft, USA) programs. Data are presented as means with standard deviation. There was no major deviation from normal distribution. Sex and age effects were tested with two-way Analysis of variance (ANOVA) with sex (2) as between factor and age (3) as within factor. Longitudinal changes were analyzed with repeated measures ANOVA, where improvement in jump performance of coordinated and non-coordinated jumpers was analyzed with repeated measures ANOVA and one fixed factor (jump coordination). The pooled longitudinal trends (our data and the data of others) were fitted by mathematical modelling using logarithmic curve to establish best fit. The Pearson correlation was used to analyze the correlation between fat mass and CMJ height. The level of significance for all tests was set at $P<.05$. If significance was confirmed, we reported also the η^2 effect size.

RESULTS

In all three-measurement points in total, 79 participants being included; their average body height, body mass, fat mass, muscle mass, CMJ height without arms, CMJ height with arms and percent of coordinated jumpers is shown in Table 1.

Table 1: Longitudinal anthropometric and jump performance data for both sexes.

Parameter	Sex	4 years	5 years	6 years	P_{sex} (η^2)	P_{age} (η^2)	$P_{age\ x\ sex}$ (η^2)
Body height / cm	Boys	108±4.8	115±5.3	121±5.6	.073	<.001 (.943)	.339
	Girls	108±4.4	116±5.0	123±5.8			
Body mass / kg	Boys	18.2±2.5	20.5±3.0	23.6±3.7	.494	<.001 (.877)	.364
	Girls	18.5±2.8	21.3±3.6	24.0±4.2			
Fat mass / %	Boys	14.2±2.4	14.6±3.3	17.2±4.7	.001 (.133)	<.001 (.293)	.701
	Girls	16.7±2.5	17.1±3.8	19.2±4.2			
Muscle mass / kg	Boys	5.7±0.9	6.6±1.0	7.7±1.2	.002 (.116)	<.001 (.881)	.194
	Girls	5.1±0.8	6.0±0.9	6.9±1.1			
CMJ height without arms / cm	Boys	9.1±3.1	11.8±3.3	13.2±3.4	.337	<.001 (.620)	.072
	Girls	8.9±2.9	12.8±3.1	14.3±2.9			
CMJ height with arms / cm	Boys	9.9±3.3	12.6±3.2	14.7±3.3	.140	<.001 (.632)	.095
	Girls	8.9±2.9	14.2±3.7	15.8±3.2			
Coordinated jumpers / %	Boys	35	53	79		<.001 (.881)	
	Girls	33	76	87			

CMJ – countermovement jump
Coordinated jumpers - subjects with excellent jumping coordination
η^2 – partial eta-squared

Body height (P<.001; η^2=.943) and body mass (P<.001; η^2=.877) increased with age, similarly in both sexes. Post hoc analysis revealed that body height in boys increased for 7 % at the age of 5 (P=.001) and for 5 % at the age of 6 (P=.001) and in girls for 7 % at the age of 5 (P=.001) and for 5.5 % at the age of 6 (P=.001). Body mass increased in boys for 13 % at the age of 5 (P=.001) and for 15 % at the age of 6 (P=.001) and in girls for 15 % at the age of 5 (P=.001) and for 13 % at the age of 6 (P=.001).

Fat mass was higher in girls than in boys (P=.001; η^2=.133) and increased with age (P<.001; η^2=.293). Post hoc analysis revealed an increase only at the age of 6 in boys for 2.6 % (P=.001) and in girls for 2.1 % (P=.001). There was no correlation between CMJ height and fat mass at any age.

On the other hand, muscle mass was higher in boys than in girls (P=.002; η^2=.116) and increased with age (P<.001; η^2=.881). Post hoc analysis revealed an increase in muscle mass in boys for 16 % at the age of 5 (P=.001) and for 17 % at the age of 6 (P=.001) and in girls for 18 % at the age of 5 (P=.001) and for 15 % at the age of 6 (P=.001).

CMJ with (P<.001; η^2=.632) and without the use of arms (P<.001; η^2=.620) increased with age, similarly in both sexes. Post hoc analysis revealed an increase in CMJ without arms in boys for 23 % at the age of 5 (P=.001) and for 11 % at the age of 6 (P=.001) and in girls for 30 % at the age of 5 (P=.001) and for 10 % at the age of 6 (P=.001). CMJ with arms increased in boys for 16 % at the age of 5 (P=.001) and for 17 % at the age of 6 (P=.001) and in girls for 18 % at the age of 5 (P=.001) and for 15 % at the age of 6 (P=.001).

After putting together our data of CMJ with arms with the data of Focke et al. (2013), we modelled developmental trends of jumping performance (Figure 2). It is evident that the trends are logarithmic, where boys exceed jumping performance of girls after the age of 7.

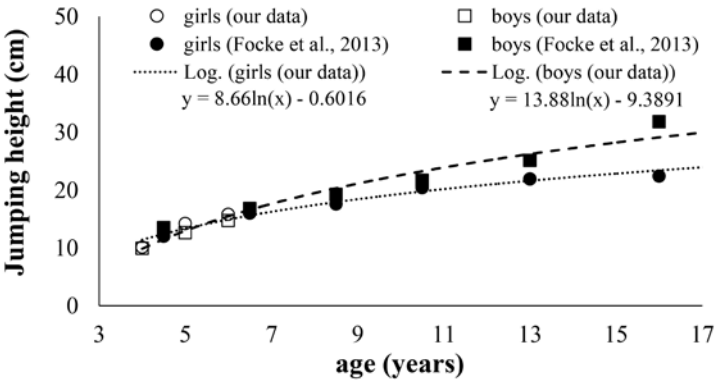


Figure 2: Comparison of countermovement jumping height (with arms) analysed by the means of force plate in relation to age and gender from the literature.

In the next analysis we compared CMJ height performance (with arms) in children classified with different jumping coordination score (1 − poor; 2 − average; 3 − excellent). Table 2 presents the percentage of children performing excellent, average and poor jumping coordination for each age. We found that the percentage of average jumpers decreases with age by about half each year. On the contrary, we see that the percentage of excellent jumpers increased. The percentage on poor jumpers is diminishing, however at the age of 6 there are still 4.4 to 5.9 % of jumpers with poor coordination.

Table 2: Percentages of poor, average, and excellent jumping coordination classifications in relation to age and sex.

Arm coordination		4 years	5 years	6 years
Poor	Boys	11,8 %	14,7 %	5,9 %
	Girls	8,9 %	2,2 %	4,4 %
Average	Boys	73,5 %	35,3 %	14,7 %
	Girls	68,9 %	24,4 %	8,9 %
Excellent	Boys	14,7 %	50,0 %	79,4 %
	Girls	22,2 %	73,3 %	86,7 %

After the classification of CMJ coordination we compared average CMJ height (with arms) of children in each jumping coordination group, pooled for both sexes (Figure 3). Obviously, the children with excellent CMJ coordination progress more intensively than others, the average coordination jumpers still show progress, whereas the children with poor coordination do not progress at all.

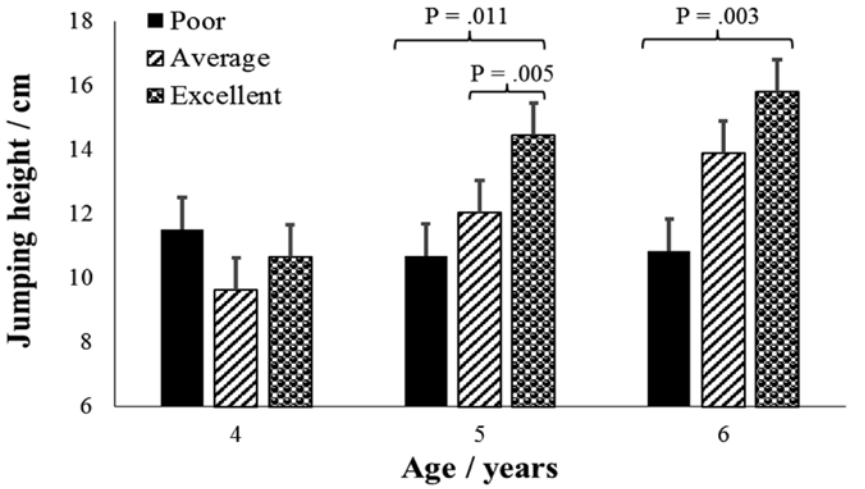


Figure 3: Age progress in countermovement jumping height (with arms) of children from each jumping coordination (poor, average, excellent), pooled for both sexes.

DISCUSSION

Our longitudinal study contributed to new insights into children's FMS, focusing on vertical jumping. We developed a developmental trend for CMJ performance increase considering the arms use. We also extrapolated our data with the data of others (non--athletes, Focke et al., 2013) and modelled a logarithmic trend in jumping performance from the age of 3 to 16. Furthermore, we presented a strong dependence of jumping performance progress with jumping coordination.

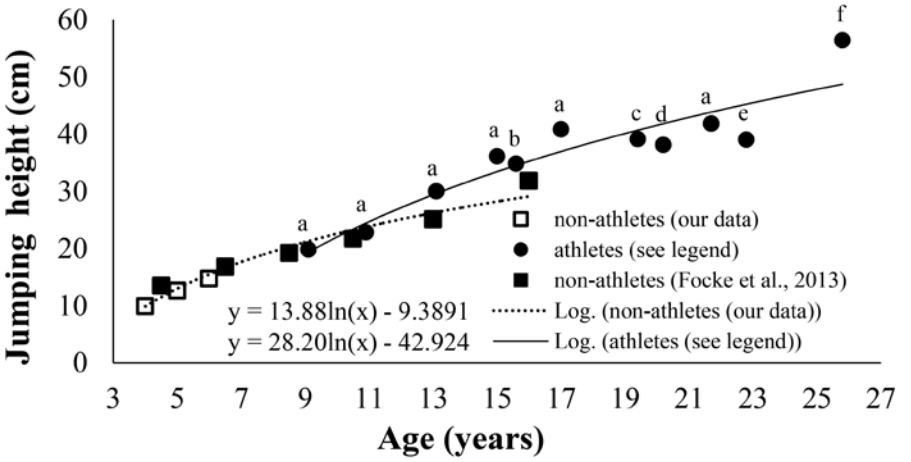
The CMJ is a commonly used method to measure leg or whole body explosive power (Richter, Jekauc, Woll, & Schwameder, 2010). Muscle composition, muscle mass and strength, body height, and jumping coordination are the most important factors of maximal jumping performance. However, at the age span of 4 to 6 we did not find any significant correlation between fat mass and CMJ height; however, we observed increasing fat mass when a child progresses from 4 to 6 years of age that is in accordance with the data of other studies (Weber, Leonard, & Zemel, 2012). It seems that increasing fat mass decreases the ability of anaerobic performance in adult population (Inacio, Dipietro, Visek, Miller, 2011), especially in adult athletes (Abidin & Adam, 2013).

From the observed CMJ height developmental trends we found significant year-to--year progress in both sexes for about 10 to 30 % per year, comparing the age of 5 (16 to 30 %) to age of 6 (10 to 17 %). The percentages of jumping progress strongly depen-

ding on lower average values at lower ages therefore might be misleading. However, later on the jumping performance increases in both sexes even more steeply after the age of 11, the boys preceding the girls at the age of 16 for about 8 to 10 %. The steeper progress at the age of 11s was found also in sprinting velocity of Slovenian children (Volmut, Pišot, & Šimunič, 2016), where girls show little improvement with age while boys continue to improve their sprinting velocity. The authors explained a vast portion of sprinting velocity improvement variance with regular organized sport exercise and contractile properties of skeletal muscles, in particular of biceps femoris, detected by Tensiomyography (Šimunič et al., 2011). Završnik et al. (2016) found significant sex differences in sprinting velocity after the age of 13 years, where boys have about 10 to 15 % higher sprinting velocity than girls. Završnik et al. (2016) also confirmed the importance of skeletal muscle contractile parameters for sprinting performance.

Focke et al. (2013) analyzed CMJ in 4- to 17-year-old children. Their data are inserted in Figure 2. They specified that boys jumped higher than girls and the difference was present in all age spans, being 12.5 % at the age of 4 to 5, 5 % at the age of 6 to 7, 9.1 % at the age of 8 to 9 years, 6.4 % at the age of 10 to 11, 14.6 % at the age of 12 to 14, and 42 % at the age of 15 to 17. The higher jump performance in boys is in line with the previously reported studies and can be explained by different gender-related physical conditions (Temfemo et al., 2009; Harrison & Gaffney, 2001). Although boys develop lower rate of force development than girls, boys jump higher than girls. It seems that the explosiveness obviously is not sufficient to guarantee better performance. However, boys are able to produce forces over a longer period of time leading to enhanced jumping height (Focke et al., 2013).

There have been numerous studies which have investigated jumping in athletes from various sports (Nikolaidis, Ingebrigtsen, Póvoas, Moss, & Torres-Luque, 2015; Yanci & Camara, 2016; Wisløff, Castagna, Helgerud, Jones, & Hoff, 2004; Cilli, Gelen, Yildiz, Saglam, & Camur, 2014; Sánchez-Muñoz et al., 2011). Apparently, at certain age they progress in jumping performance more steeply than non-athletes (Figure 4). From Figure 4 it is evident that the athletes older than 11 precedes non-athletes in the performance. Before that age there are actually no differences.



a − Nikolaidis et al. (2015); b − Sánchez-Muñoz et al. (2011); c − Pagaduan, Pojskić, Užičanin, and Babajić (2012); d − Cilli et al. (2014); e − Yanci and Camara (2016); f − Wisløff et al. (2004).

Figure 4: Comparison of countermovement jumping height (with arms) of boys in relation to age and sport participation.

We have also presented the effect of arm swings coordination on jump performance. This has been also a focus of other studies, but in adult population (Payne, Slater, & Telford, 1968; Miller, 1976; Shetty & Etnyre, 1989; Harman et al., 1990). In the vertical jump, as well as in many other sports skills, the arms are swung vigorously upwards during the take-off to enhance performance (Lees, Vanrenterghem, & Clercq, 2004). The arm swing can increase the ground reaction force in the latter half of the propulsive phase, leading to enhanced net ground reaction impulse. Consequently, the center of mass position and vertical velocity at the take-off can also be raised, which increases the jump height (Cheng, 2008). Feltner, Bishop and Perez (2004) showed that the arm swing decreases extensor joint torques early in the propulsive phase but augments these same extensor torques later in the propulsive phase. The increased jump height consists of increased center of mass height (54 %) and vertical velocity (46 %) at the take-off, while a different percentage distribution (28 % and 72 %, respectively) was found by Lees et al. (2004). Hara, Shibayama, Takeshita and Fukashiro (2006) studied the effect of the arm swing on lower extremities in vertical jumping. They concluded that an increased jump height is mainly due to increased work done by the lower extremities, which also comes as a result of the additional load on the lower extremities because of the arm swing. Although an increased take-off velocity is reported consistently when

arms are swung, the mechanisms by which arm swing leads to an increase in the take--off velocity have not been fully established (Lees et al., 2004; Harman et al., 1990; Shetty & Etnyre, 1989).

Proper use of the arms assures the optimal use of stretch shortening cycle, where Harrison and Gaffney (2001) found that 6 year-old children could utilize the SSC in vertical jumping equally well compared to adults. Harrison and Moroney (2007) found also that girls at age 6.6 ± .5 years) appear to be equally effective to adult woman aged 22.1±1.2 years in using the arms to improve jumping performance. Moreover, results indicated that the arm action significantly improved performance in both adults (woman) and children (girls) and adults jumped significantly higher than children irrespective of whether arm action was used. Improvements in performance of the jump may be due more to differences in body stature and muscle strength and power rather than coordination and control (Harrison & Moroney, 2007).

Study Limitations

The limitations of the study are in the selection of the research environment, namely only one Slovenian region was selected for performing this study. Furthermore, there are no objective data of their physical status or habits available for the whole group of participants.

CONCLUSION

This research focused on studying 4 to 6 year-old children's FMS, vertical jump. We found no sex differences, but confirmed age-related CMJ height increase as well as strong dependence of CMJ height increase with engaged jumping coordination. We conclude that jumping coordination is the most important factor of jumping performance in the studied age span.

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REPORTS AND REVIEWS/POROČILA IN OCENE, 171–180

THE 21ST ANNUAL CONGRESS OF THE EUROPEAN COLLEGE OF SPORT SCIENCE

Vienna, Austria, 6th – 9th July 2016

The 21st Annual Scientific Congress "European College of Sport Science (ECSS)" took place in Vienna (Austria) between 6th and 9th July 2016. This was the second biggest ECSS congress in history (after the ECSS Barcelona 2013) with a total of 2,783 researchers from all over the world who attended the event. The participants presented their latest discoveries in their respective scientific fields such as physiology, sports training and measurement, health and endurance, sports medicine and orthopedics, biomechanics and other.

Similarly, the competition for young researchers (ECSS Young Investigator Award 2016 Contest) took place at ECSS in Vienna. In this context, two researchers from the University of Primorska (Slovenia) won their prizes. Out of the total of 421 competitors, Assistant Professor Uroš Marušič, Ph.D., and Assistant Professor Borut Fonda, Ph.D., entered the finals competing with 116 best young investigators and won the fourth and the fifth place, respectively.

Assistant Professor Uroš Marušič, Ph.D., presented his article titled "Mental Simulation of Locomotor Tasks Improves Rehabilitation Outcome in Elderly Adults after Hip Surgery", which included results from a twelve- month "PANGeA Hip Study" and presented an innovative concept of rehabilitation after hip replacement.

Assistant Professor Borut Fonda, Ph.D., presented his work titled "The Effect of the Medial-Lateral Force during Cycling" where he underlined some practical aspects of measuring forces on pedals during cycling in order to achieve optimization of efficiency and prevention of injuries.

Additional information on the ECSS can be found on the following links:
http://sport-science.org/index.php?option=com_content&view=article&id=599
http://sport-science.org/index.php?option=com_content&view=article&id=600

The next Congress is foreseen to take place in Essen (Germany), from 5th to 8th July 2017.

Uroš Marušič

REPORTS AND REVIEWS/POROČILA IN OCENE, 171–180

21. LETNI ZNANSTVENI KONGRES »EUROPEAN COLLEGE OF SPORT SCIENCE«

Dunaj, Avstrija, 6.-9. julij 2016

21. letni znanstveni kongres »European college of sport science (ECSS)« je potekal na Dunaju (Avstrija) med 6. in 9. julijem 2016. Po številu udeležencev je bil to drugi največji ECSS kongres do sedaj, takoj za ECSS v Barceloni (leta 2013), z udeležbo kar 2783 raziskovalcev iz celotnega sveta. Udeleženci kongresa so predstavili svoje najnovejše ugotovitve na različnih znanstveno-raziskovalnih področjih, kot so npr. fiziologija, treniranje in merjenje, zdravje in zmogljivost, športna medicina in ortopedija, biomehanika, itd.

Prav tako kot pretekla leta je v okviru ECSS na Dunaju potekalo tekmovanje mladih raziskovalcev (ECSS Young Investigator Award 2016 contest), v okviru katerega sta nagradi osvojila tudi raziskovalca z Univerze na Primorskem. Izmed skupno 421 tekmovalcev, sta doc. dr. Uroš Marušič in doc. dr. Borut Fonda prišla v »ožji« izbor 116-ih mladih raziskovalcev ter na koncu dosegla prestižni 4. in 5. mesto.

Doc. dr. Uroš Marušič je predstavil prispevek z naslovom »Mental Simulation of Locomotor Tasks Improves Rehabilitation Outcome in Elderly Adults after Hip Surgery«, kjer je z rezultati enoletne študije »PANGeA hip study« predstavil inovativen koncept rehabilitacije po zamenjavi kolka.

Doc. dr. Borut Fonda je predstavil prispevek z naslovom »The Effect of the Medial-Lateral Force during Cycling«, kjer je izpostavil praktični pomen meritev sil na pedalih med kolesarjenjem za optimizacijo učinkovitosti in preprečevanje poškodb.

Več informacij o kongresu in nagradah je dostopnih na spletnih naslovih:

http://sport-science.org/index.php?option=com_content&view=article&id=599

http://sport-science.org/index.php?option=com_content&view=article&id=600

Naslednji kongres ECSS bo 22. po vrsti, potekal pa bo med 5. in 8. julijem v Essnu, Nemčija.

Uroš Marušič

REPORTS AND REVIEWS/POROČILA IN OCENE, 171–180

INTERNATIONAL CONFERENCE "SPORT SCIENCE AND SPORT AS A REGULAR COMPONENT OF THE LIFE STYLE"

Sharm El-Sheikh, Egypt, 1st–3rd November 2016

Faculty of Physical Education, University`of Assiut (Egypt), in cooperation with the Institute of Sport Science, University of Magdeburg (Germany), organized the International Conference "Sport Science and Sport as Regular Component of the Life Style", which took place from 1st to 3rd November, 2016. The aim of the Conference was to bring together sport scientists, experts and professionals from around the world to share their knowledge and ideas in the light of new advancements in sport sciences and in the connected areas through the multidisciplinary approach raised at the conference in order to discuss the ways of development in the sports field. In addition, to support the interaction and the dialogue between different organizations and international sports bodies, thus the work on providing the inter-Arab collaboration with European countries through upgrading the level of exchange to the level of coordination and knowledge integration. Therefore, more than two hundred scientists and researchers from ten countries and three continents presented their work from the fields of s physical education, motor control and learning, recreation, health and aging, and also sport in general i.e. sports tourism, sports management, sports psychology and sociology. The accepted abstracts were published in the Book of Proceedings 2016.

The scientific programme included plenary sessions by eminent international experts: Rado Pišot (University of Primorska; Slovenia) who focused his lecture on the importance of physical activity in contemporary society; Elke Knisel (University of Magdeburg; Germany) presented the model of health promotion at schools. Moreover, Anita Hokelmann (University of Magdeburg; Germany) exposed the latest research in neuroscience on the scope of neural plasticity in response to physical activity, while Hagen Wasche (University of Karlsruhe; Germany) presented a new way of social network analysis in sport research.

Furthermore, this conference was also attended by the young researcher Armin Paravlić, a member of Institute of Kinesiology Research, University of Primorska, who actively participated in presenting the latest scientific research of the Institute, related to the modified approach of measuring electromechanical muscle efficiency. We can say that the Conference was successful not only from the scientific but also from social aspects, and it has surely accomplished its objectives.

Armin Paravlić

REPORTS AND REVIEWS/POROČILA IN OCENE, 171–180

MEDNARODNA KONFERENCA »ZNANOST O ŠPORTU IN ŠPORT KOT REDNA KOMPONENTA ŽIVLJENJSKEGA SLOGA«

Sharm El-Sheikh, Egipt, 1.–3. november 2016

Fakulteta za športno vzgojo Univerze v Assiuntu (Egipt), je v sodelovanju z Inštitutom za znanosti o športu Univerze v Magdenburgu (Nemčija), organizirala mednarodno konferenco z naslovom Znanost o športu in šport kot redna komponenta življenjskega sloga, ki je potekala od 1. do 3. novembra 2016 v Sharm El-Sheikhu v Egiptu. Namen konference je bil združiti znanstvenike, strokovnjake in profesionalce za področje športa iz celega sveta. Kot vodilo je bil na konferenci postavljen multidisciplinaren pristop, udeleženci pa so izmenjavali svoje znanje in ideje na osnovi novih dognanj v športnih znanostih in sorodnih področjih ter razpravljali o možnostih razvoja na področju športa. Dodaten namen konference je bil podpora interakciji in dialogu med različnimi organizacijami in mednarodnimi športnimi organi, s čimer bi zagotovili medarabsko sodelovanje z evropskimi državami in nadgradili nivo izmenjave na raven usklajevanja in povezovanja znanja. V teh okvirih je več kot dvesto znanstvenikov in raziskovalcev iz desetih držav in treh celin predstavilo svoje delo s področij športne vzgoje, motoričnih sposobnosti in učenja ter rekreacije, zdravja in staranja, pa tudi športa na splošno, tj. športnega turizma, upravljanja v športu, športne psihologije in sociologije. Zbrani povzetki so predstavljeni v zborniku Book of Proceedings 2016.

Znanstveni program je vseboval plenarna predavanja uglednih mednarodnih strokovnjakov: Rado Pišot (Univerza na Primorskem, Slovenija), ki je svoje predavanje namenil pomembnosti fizične aktivnosti v današnji družbi; Elke Knisel (Univerza v Magdenburgu, Nemčija) je predstavila model promocije zdravja v šolah. Poleg tega je Anita Hokelman iz Univerze v Magdenburgu v Nemčiji predstavila najnovejše raziskave na področju nevroznanosti omejene na nevroplastičnost glede na odziv na fizično aktivnost, medtem ko je Hagen Wasche (Univerza v Karlsruhe, Nemčija) predstavil nov način analiz družbenih omrežij pri športnih raziskavah.

Konference se je udeležil tudi mladi raziskovalec Armin Paravlić, član Inštituta za kineziološke raziskave Znanstveno-raziskovalnega središča Univerze na Primorskem, ki je aktivno sodeloval pri predstavitvi najnovejše znanstvene raziskave Inštituta, povezane s spremenjenim pristopom k merjenju elektromehanske učinkovitosti mišic. Potrdimo lahko, da je bila konferenca uspešna, ne le zaradi znanstvenih, ampak tudi zaradi socialnih vidikov, in je gotovo dosegla zastavljene cilje.

Armin Paravlić

REPORTS AND REVIEWS/POROČILA IN OCENE, 171–180

REPORT FROM THE ROUND TABLE "A KINESIOLOGIST IN THE LABOUR MARKET"

Slovenian Association of Kinesiology,
Science and Research Centre of Koper, Institute for Kinesiology Research
Koper, 8th November, 2016

Kinesiology is a young science whose main content is the study of human movement (physical activity). In a broader sense, kinesiology is the science that examines the nature principles and the management process of human movement and the effects of these processes on the human organism in relation with its living and working environment. In Slovenia, the formal study of kinesiology is possible in two study programs, namely, the program of (Applied) Kinesiology at the University of Primorska and the program of Kinesiology at the University of Ljubljana, Faculty of Sport. Kinesiology as the field of study has been in the constant development since 2010. Nowadays, first kinesiologists, B.Sc. and M.Sc. are successfully placed within the labour market.

The profession of kinesiologist is one of the youngest professions in Slovenia. In the description of the Standard Classification of Professions (SKP-08) the profession of kinesiologist is described as a health expert / specialist. The content of kinesiology and the occupation of kinesiologist is placed among the fields of health, sports and safety and occupational health. Currently, the profession is systemically placed in the existing as well in the new draft to *Sports Act*. Thus, a kinesiologist is an educated expert in the field of sport and thereby a regulated profession in Slovenia. As an educated expert it is placed also in the *Resolution on the national program on nutrition and physical activity for health in 2015 − 2025*. Continuous efforts are being made to place the profession of kinesiologist also in the national system in health field and in the area of health and safety at work.

In accordance with the placement of kinesiology and kinesiologists in the content of modern society, their main competencies / skills are as followed:

- Designing health promotion programs;
- Planning and implementation of preventive health programs;
- Planning, implementation, evaluation and analysis of programs of exercise / sport activity for health;
- Participating in the implementation of therapeutic and rehabilitation programs;
- Implementing the programs of exercise / sports activities for different age and target groups (children, adults, seniors, persons with disabilities, persons with chronic non-communicable diseases, like asthma, diabetes, ...);
- Implementing the preventive measures of physical characteristics, motor abilities, and their use in the preparation of the system and / or individually tailored prevention programs;
- Designing and implementing a basic ergonomic analysis of the workplace and preparing measures to improve the health of the selected job;

– Implementing programs of condition training in elite sport;
– Participating in and advising on the procedure of planning physically and movement stimulating environments.

With these and other specific competences and skills, kinesiologists are employable in the public sector (e.g. Collaborator and Referee for Sport in municipalities), as operators of national projects (Healthy Lifestyle, Human Resources Development in the Sport, Together for Health, The National Program of Sport Discipline in schools...) or independently on the labour market, employed by companies (e.g. private retirement homes, spas, hotels or sports centers ...) or as self-employed.

On 8th November 2016, the Slovenian Association of Kinesiology together with Science and Research Centre of Koper, Institute for Kinesiology Research organized a round table titled "Kinesiologist in the Labour Market" in the library of the Scientific Research Centre of Koper in order to open a conversation on the topic of employability of kinesiologists between the representatives of different institutions and organizations. Official guests of the round table were Boro Štrumbelj, Ph.D., Director General of Directorate of Sport from the Ministry of Education, Science and Sport, Assoc. prof. Edvard Kolar, Ph.D., Secretary General of the Olympic Committee of Slovenia, prof. Rado Pišot, PhD., Director of the Science and Research Centre Koper and the President of Slovenian Association of Kinesiology, prof. Damir Karpljuk, Ph.D., vice-dean of the Faculty of Sport, University of Ljubljana, Mr. Marjan Plavčak, the President of the Slovenian Association of Physical and Sport Teachers, Vedran Hadžič, PhD., the Kinesiology Study Program Coordinator at the University of Ljubljana, Matej Plevnik, Ph.D., a lecturer at the study program Applied Kinesiology at the University of Primorska, Anja Andrenšek, an undergraduate studentof applied kinesiology at University of Primorska and Maja Dakskobler, Univ. Sc. kin., a Kinesiology graduate from the University of Ljubljana.

Kinesiology students and other guests filled the venue.

The contents of the round table was divided in four topics, namely, a kinesiologist's competences, the current employment opportunities for kinesiologists, the relationship between education programs and the training in the field of sport and an insight into the future directions and the development of kinesiology. Guests noted that a kinesiologist as an educated professional is placed in the existing Sports Act, as well as in the draft of the new Act, which will be accepted in the near future. They shared the opinion that the society needs educated professionals from the field which covers kinesiology, but that it is also necessary to make further efforts to expand the knowledge of the profession and its fields of activity, especially in the area of health and safety and health at work. As examples of good practice they mentioned some cases where kinesiologists are well-placed in the labour market, as well as the projects and financial mechanisms through which they are incorporated into the labour market (Healthy Lifestyle, Human Resources Development in the Sport, Together for Health, The National Program of Sport Discipline and others). The event was concluded with the decision that it is necessary to strive for greater integration of the institutions that educate kinesiologists in Slovenia and make further efforts for the spread of systemic arrangements in the field of employment for kinesiologists and the promotion of kinesiology as a professional field and a scientific discipline. Younger colleagues expressed their hopes for their older, already graduated colleagues, to help create new employment opportunities through their good work and through setting the examples for them.

Matej Plevnik, Rado Pišot

REPORTS AND REVIEWS/POROČILA IN OCENE, 171–180

POROČILO Z OKROGLE MIZE »KINEZIOLOG NA TRGU DELA«

Društvo kineziologov Slovenije,
Znanstveno-raziskovalno središče Koper, Inštitut za kineziološke raziskave
Koper, 8. november 2016

Kineziologija je mlada znanost, katere osrednja vsebina je preučevanje gibanja človeka. V širšem pomenu besede je kineziologija znanost, ki preučuje zakonitosti upravljanja procesov gibanja človeka in posledice delovanja teh procesov na človekov organizem, v odvisnosti in povezavi z njegovim življenjskim in delovnim okoljem. V Sloveniji je študij kineziologije mogoč na dveh študijskih programih, in sicer programu Aplikativne kineziologije na Univerzi na Primorskem ter programu Kineziologije na Univerzi v Ljubljani. Študijsko področje kineziologije je v razvoju od leta 2010 dalje, danes pa se na trg dela uspešno umeščajo prvi diplomirani kineziologi in magistri kineziologije.

Poklic **kineziologa** je v Sloveniji eden mlajših. V standardni klasifikaciji opisa poklicev (SKP-08) je poklic kineziologa opisan kot zdravstveni strokovnjak/strokovnjakinja. Vsebinsko se polje delovanja umešča med zdravstvo, šport in varnost ter varovanje zdravja pri delu. Sistemsko je trenutno umeščen v obstoječi, kot tudi novi predlog *Zakona o športu.* Tako je kineziolog tudi izobražen strokovnjak na področju športa in s tem reguliran poklic v Sloveniji. Kot izobražen strokovnjak je umeščen tudi v *Resolucijo o nacionalnem programu o prehrani in telesni dejavnosti za zdravje 2015 – 2025*. Ves čas potekajo prizadevanja, da bi poklic kineziologa vsebinsko primerno sistemsko umestili tudi na področju zdravstva in na področju zdravja in varnosti pri delu.

Skladno z umestitvijo kineziologa, so njegove glavne kompetence/veščine naslednje:

- Oblikovanje programov promocije zdravja,
- Načrtovanje in izvedba preventivnih programov zdravja,
- Načrtovanje, izvedba, vrednotenje in analiza programov gibalne/športne aktivnosti za zdravje,
- Sodelovanje pri izvajanju terapevtskih in rehabilitacijskih programov,
- Vodenje programov gibalne/športne aktivnosti za različne starostne in ciljne skupine (otroci, odrasli, starostniki, osebe s posebnimi potrebami, osebe s kroničnimi nenalezljivimi boleznimi – astma, sladkorna bolezen, …),
- Izvajanje preventivnih merjenj telesnih značilnosti in gibalnih sposobnosti ter njihova uporaba pri pripravi sistemskih in/ali individualno prilagojenih preventivnih programov,
- Načrtovanje in izvajanje osnovnih ergonomskih analiz delovnega mesta in priprava ukrepov za izboljšanje zdravja na izbranih delovnih mestih,
- Izvajanje programov kondicijske vadbe v vrhunskem športu
- Sodelovanje in svetovanje pri načrtovanju gibalno spodbudnega okolja.

Kineziologi so z omenjenimi in drugimi specifičnimi kompetencami zaposljivi v javnem sektorju (npr. kot referenti za šport na občinah), kot izvajalci nacionalnih projektov (Zdrav življenjski slog, Razvoj kadrov v športu, Za boljše zdravje in zmanjšanje neenakopravnosti v zdravju, Program športnih panožnih šol…) oziroma samostojno na trgu dela, pri podjetjih (npr. zasebni domovi starejših, zdravilišča, hotelski ali športni centri…) ali kot samozaposleni.

Društvo kineziologov Slovenije in Znanstveno-raziskovalno središče Koper, Inštitut za kineziološke raziskave, sta 8. novembra 2016 v knjižnici Znanstveno-raziskovalnega središča UP organizirala okroglo mizo z naslovom »Kineziolog na trgu dela«. Osnovni namen okrogle mize je bil odprt pogovor med predstavniki različnih ustanov na temo zaposljivosti kineziologa. Uradni gostje okrogle mize so bili dr. Boro Štrumbelj, generalni direktor Direktorata za šport, Ministrstva za izobraževanje, znanost in šport, izr. prof. dr. Edvard Kolar, generalni sekretar Olimpijskega komiteja Slovenije, prof. dr. Rado Pišot, direktor Znanstveno-raziskovalnega središča UP, prof. dr. Damir Karpljuk, prodekan Fakultete za šport, UL, g. Marjan Plavčak, predsednik Zveze društev športnih pedagogov Slovenije, doc. dr. Vedran Hadžič, koordinator študijskega programa Kineziologija na Fakulteti za šport, UL, doc. dr. Matej Plevnik, predavatelj na študijskem programu Aplikativna kineziologijae UP FAMNIT, Anja Andrenšek, absolventka – študentka aplikativne kineziologije UP FAMNIT ter Maja Dakskobler, univ. dipl. kin. (UL FŠ).

Študentje kineziologije in ostali poslušalci so napolnili prostor dogodka.

Vsebina okrogle mize je bila strnjena v štiri vsebinske sklope: kompetence kineziologa, trenutne zaposlitvene možnosti kineziologa, razmerja med izobraževanjem in usposabljanjem na področju in pogled v prihodnost poklica kineziologa. Gostje so

ugotovili, da je kineziolog, kot izobražen strokovni delavec, umeščen tako v obstoječi Zakon o športu kot tudi osnutek novega zakona, ki bo predvidoma sprejet v bližnji prihodnosti. Enotni so si bili, da obstaja potreba po izobraženem kadru tega profila, da pa si je potrebno tudi nadalje prizadevati za širitev prepoznavnosti poklica in njegovih področij delovanja, predvsem na področja zdravstva ter varnosti in zdravja pri delu. Omenili so primere dobre prakse, iz katerih je razvidno, da se kineziologi kot strokovni sodelavci dobro umeščajo na trgu dela, kot tudi projekte in finančne mehanizme, skozi katere so vključeni na trg dela (Zdrav življenjski slog, Razvoj kadrov v športu, Za boljše zdravje in zmanjšanje neenakosti v zdravju in drugi). Dogodek so zaključili s sklepom, da si je potrebno prizadevati za večje povezovanje inštitucij, ki izobražujejo kineziologe v Sloveniji ter si nadalje prizadevati za širjenje sistemske ureditve področja zaposlovanja kineziologov in promocije polja kineziologije. Mlajši kolegi pa so priporočili starejšim že diplomiranim, da s svojim zgledom in dobrim delom ustvarjajo nove zaposlitvene možnosti tudi za njih.

Matej Plevnik, Rado Pišot

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Journal articles
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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.

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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.*

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