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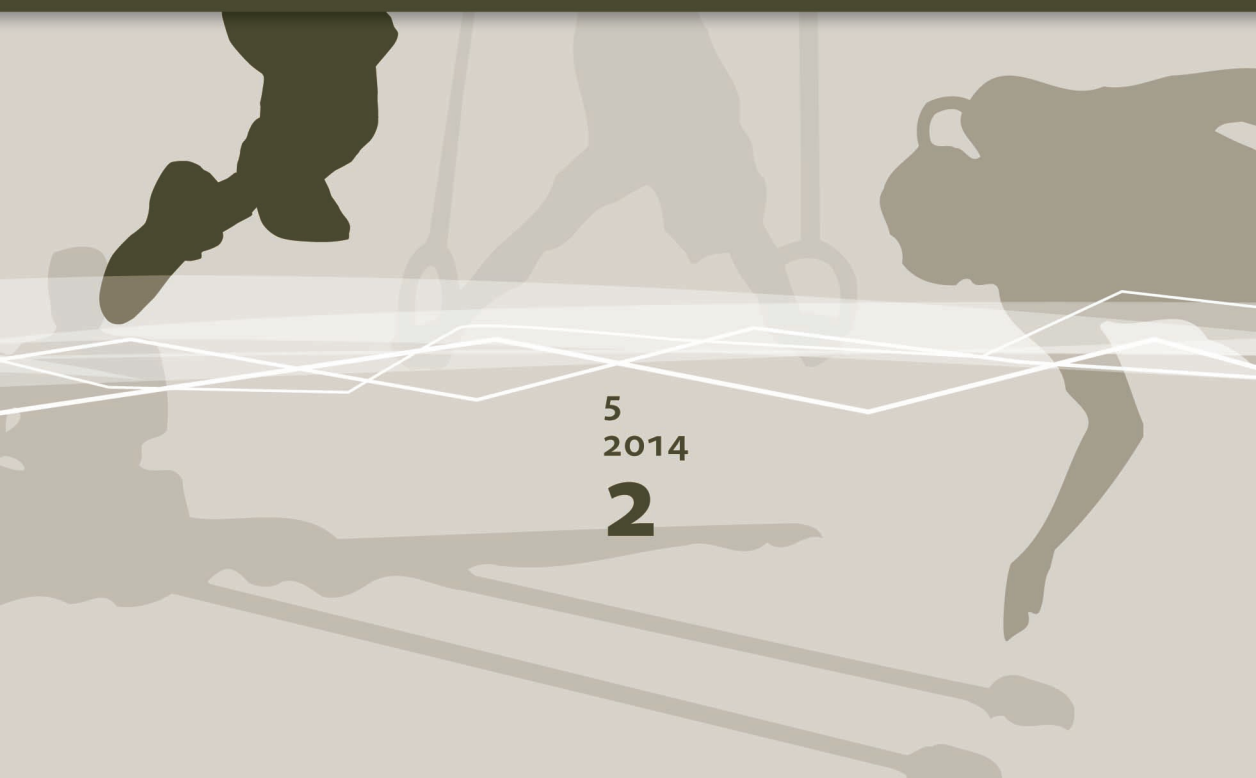

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TABLE OF CONTENTS

REPORTS
POROČILA

EDITORIAL

We are glad to introduce the second issue of the Annales Kinesiologiae Journal's 5th volume. Kinesiology, as a growing, interdisciplinary scientific field, is gaining an increasingly important role and responsibility in promoting an active lifestyle and ensuring the healthy and harmonious development of each individual. With this in mind, this issue includes five scientific articles covering different target groups at different stages of life. We have selected two papers, previously presented at the 8th International Scientific Conference "Child in Motion" in Bernardin, Slovenia and two papers at the 7th International Scientific Conference on Kinesiology in Opatija, Croatia, in 2014.

The opening article points to the definition of the healthiest body weight for children and adults. Lorenzini emphasizes the importance of body weight reduction as part of a strategy to improve health and life span while reducing pathologies. In the article titled "The role of dynamic systems in motor development research: metaphor or notable reality?", Šerbetar discusses the possibility of applying a new theory of motor control within the context of motor development theories and research. Given the importance of physical activity in the development of children and adolescents, Pušnik and his colleagues investigated the quantity and intensity of physical activity during physical education in third grade primary school children. Evaluating the influence of caffeine ingestion on maximum power output during endurance performance in athletes, Smolka and Kumstát concluded that caffeine intake enhances endurance performance in sub-elite but not in elite athletes. Finally, Logar and colleagues presented a pilot study analyzing the differences in the knee torque between high- and low-bar back squat techniques, indicating a possibility of a reduced knee joint load using the low-bar back squat technique.

The content diversity of such contributions represents significant added value for the science of kinesiology, particularly with regard to its integrative nature. The last section of the journal is dedicated to conference report. We hope you will find the topics of the articles published in this issue interesting and we wish you all the best in 2015!

Petra Dolenc,
Guest Editor

UVODNIK

Z veseljem vas vabimo k branju druge številke petega letnika revije Annales Kinesiologiae. Kineziologija ima kot rastoča interdisciplinarna znanost v sodobni družbi vse pomembnejšo vlogo in odgovornost pri spodbujanju aktivnega življenjskega sloga ter zagotavljanju zdravega in uravnoteženega razvoja vsakega posameznika. V duhu slednjega so vsebine v pričujoči številki namenjeni različnim ciljnim skupinam v različnih življenjskih obdobjih. Večina izbranih prispevkov je bila predstavljena na znanstvenih konferencah, ki sta potekali v letu 2014 – 8. mednarodna znanstvena konferenca Otrok v gibanju, Bernardin, Slovenija in 7. Mednarodna znanstvena konferenca o kineziologiji, Opatija, Hrvaška.

V uvodnem prispevku je izpostavljen pomen opredelitve zdrave telesne teže pri otrocih in odraslih. Lorenzini poudarja pomen zmanjšanja telesne teže kot dela strategije za izboljšanje zdravja in kakovosti življenja. V članku z naslovom Vloga dinamičnih sistemov v raziskavah gibalnega razvoja: samo metafora ali pomembna realnost? Šerbetar razpravlja o možnostih aplikacije nove teorije motorične kontrole v kontekstu teorij in raziskav gibalnega razvoja. Glede na pomen gibalne aktivnosti v razvoju otrok in mladostnikov so Pušnik in sodelavci ugotavljali količino in intenzivnost gibanja pri učencih tretjega razreda osnovne šole pri pouku športa. V raziskavi o učinkih kofeina na maksimalno moč med vzdržljivostno vadbo pri športnikih sta Smolka in Kumstát ugotovila, da uživanje kofeina izboljša vzdržljivost pri amaterskih športnikih, ne pa tudi pri vrhunskih športnikih. Logar s sodelavci v pilotni študiji analizira razlike v navoru kolena pri različnih tehnikah počepa, pri čemer avtorji ugotavljajo možnost manjših obremenitev na kolenski sklep pri izvedbi počepa z uporabo tehnike z nizko postavitvijo droga za glavo.

Vsebinska raznolikost prispevkov pomeni pomembno dodano vrednost za kineziološko znanost, zlasti v povezavi z njeno integrativno naravo. Sklepni del revije je namenjen poročilu s konference. V upanju, da boste revijo z zanimanjem prebirali, vam želimo vse dobro v letu 2015!

Petra Dolenc,
gostujoča urednica

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ON THE DEFINITION OF THE HEALTHIEST BODY WEIGHT FOR CHILDREN AND ADULTS

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ABSTRACT

Ongoing changes in societies are driving an expanding fraction of the world's population towards a sedentary and overfed lifestyle. An overwhelming amount of data has linked increased body weight with an increased risk of acquiring a number of major diseases. Gerontologists, in order to extend the life span of laboratory animals, have used caloric restriction successfully for decades. This basic research on animals along with epidemiological data taken from vast human cohorts is cumulatively indicating that reducing one's body weight should be part of the strategy to increase health and life span while reducing pathologies. What is not a trivial matter is defining the correct weight for each individual. This mini review raises some discussion points regarding this important public health issue.

Keywords: *longevity, life span, caloric restriction, dietary restriction, body weight, body mass index, mortality.*

DEFINIRANJE NAJBOLJ ZDRAVE TELESNE TEŽE PRI OTROCIH IN ODRASLIH

IZVLEČEK

Spremembe, ki potekajo v sodobnih družbah, vodijo vedno večji delež svetovnega prebivalstva k sedečemu življenjskemu slogu s preobilno prehrano. Velika količina podatkov povezuje povečano telesno težo s povečanim tveganjem za različna oboljenja. Gerontologi že desetletja uspešno uporabljajo metodo omejevanja vnosa kalorij pri laboratorijskih živalih, ki jim želijo podaljšati življenjsko dobo. Take osnovne raziskave na živalih, skupaj z epidemiološkimi podatki, pridobljenimi pri velikih človeških izvornih skupinah, kumulativno kažejo, da bi moralo biti zmanjšanje posameznikove telesne teže del strategije za povečanje zdravja in podaljšanje življenjske dobe, obenem pa bi moralo zmanjšati patologije. Kar ni zanemarljivo, je tudi opredelitev pravilne teže za vsakega posameznika. Ta kratek pregled torej sproža mnoge razprave v zvezi s pomembnimi dejstvi o javnem zdravju.

Ključne besede: *dolgoživost, življenjska doba, omejevanje vnosa kalorij, omejevanje hrane, telesna teža, indeks telesne mase, smrtnost*

INTRODUCTION

Urbanization and socio-economic changes in societies have driven a gradual change in an increasing fraction of the world's population towards a more sedentary and overfed lifestyle. One parameter clearly affected by this lifestyle change is body weight. An overwhelming amount of scientific data (for example, see Visscher & Seidell, 2001) has linked increased body weight with an increased risk of acquiring a number of major diseases (cardiovascular, type 2 diabetes mellitus, cancer, osteoarthritis and others). This risk is higher when a person is classified as being obese or overweight early on in adult life and even worse during one's period of growth and development. The World Health Organization has indeed recently established a Commission on Ending Childhood Obesity (Commission on Ending Childhood Obesity, 2014). A biological explanation for the reason why childhood obesity may represent a higher public health risk than adult obesity can be found in the way adipose tissue develops. Fat tissue adopts two strategies to store more fat in the case of obesity: by increasing the number of adipocytes (hyperplasia) or by increasing the volume of every single adipocyte (hypertrophy). Several studies on rats have shown that the first strategy seems to be favoured during growth and development stages (see for example Oscai et al., 1974). A more recent study has also confirmed this in humans (Spalding et al., 2008). This last study has also shown that when significant weight loss is achieved through bariatric surgery in adulthood, a decrease in the average adipocyte volume, but not in adipocytes numbers

is observed. We can interpret and summarize these results to suggest that childhood obesity favours hyperplasia while adult obesity favours hypertrophy. Fat tissue with higher cellularity is very likely more efficient in storing calories and consequently is a more obstinate adversary to weight loss treatments.

This mini-review is the transcription of my lecture at the 8th International Conference A Child in Motion "Kinesiology – A Path of Health", held in Portorož, Slovenia in October 2014. In this paper I will discuss observations collected from the studies on caloric restriction and from epidemiological research that are dealing with the relation between mortality and body mass index (BMI). BMI is not the sole measure to estimate body fat; waist circumference, waist-to-hip ratio, plicometry and direct assessment of % body fat with techniques such as bioimpedentiometry are other ways of evaluating obesity that can also be combined. BMI is still commonly used both by doctors and in the public literature as a simple way to alert people regarding their weight. The World Health Organization is providing detailed BMI data for every country in a particular section on its web site that presents the "Global Database on Body Mass Index". I will try to prove that we lack a solid definition of healthy body weight and I will conclude with some considerations regarding future directions that should be considered by the science for healthy life style.

CALORIC RESTRICTION AND LONGEVITY

Correct nutrition and proper physical activity are considered the two pillars for a healthy life style.

Correct nutrition means an appropriate balance among macro- and micronutrients as well as an appropriate quantity of calories consumed to sustain an active life and at the same time to ensure the capacity to reach the genetically determined longevity potential of an individual. A recent large study has concluded that, at least in the case of mice, the best nutrition for a longer life span is the one mainly based on carbohydrates (Solon-Biet et al., 2014). There is a large amount of specialized literature on what is the best caloric intake for reaching the highest longevity. This literature provides ample experimental evidence that calorically restricting the diet in many experimental animals results in an extension of life span compared with the life span of animals with an unrestricted access to food (for a review see Matzko at al., 2009). A calorically restricted diet is a diet where the tested animals received a reduction in caloric intake usually a 30 or 40 % of the unrestricted diet consumed by control animals. Caloric restriction, of course, in the vast majority of cases, reduces body weight and the percentage of body fat.

Also, higher physical activity levels have been reported as having a positive effect on life span. This has been observed by comparing two or more groups of animals with different activity levels (e. g. Holloszy & Schechtman, 1993) or, for humans, when athletes' life spans were compared with the general population (e. g. Marijon et al., 2013).

The American College of Sports Medicine and the American Heart Association have published their recommendations regarding the minimum amount of physical activity necessary to realize health-related improvements (Haskell et al., 2007). Additionally, it is interesting to consider that in a prospective analysis on older Americans, muscle mass relative to body height was associated inversely with all-cause mortality (Srikanthan & Karlamangla, 2014).

From a gerontological point of view, if we look at how a survival curve of a cohort of laboratory rodents is modified by either nutritional or exercise interventions we can identify important differences. Caloric restriction increase both average and maximum life span while physical activity increases only average life span (Holloszy & Schechtman, 1991). Gerontologists have interpreted this difference in the following way. Increased physical activity level creates a better "metabolic environment" lowering the risk of diseases (for a recent review on the biology of exercise, see Hawley et al., 2014). Caloric restriction, however, together with creating a better "metabolic environment" could also slow down the process of aging.

The phenomenon of caloric restriction has been observed experimentally for the first time in rats (McCay et al., 1935) and following this initial observation the experiment was performed in many other animal species, including dogs and cows. One important aspect to consider when analyzing caloric restriction experiments in rodents is that the restricted diet is often applied soon after weaning, i.e. during development. Consequently, not only the restricted animal are leaner (they have less body fat) but they are actually smaller (smaller dimensions with a reduction in fat free mass). Restricting calories during development can indeed slow down growth and result in smaller adults. It is interesting to note that there are several species where smaller size is associated with increased longevity: dogs (Greer et al., 2011), horses (Austad, 2010) and even humans. For humans, Samaras and colleagues have observed that between different ethnic groups smaller size is associated with longer life span and that lighter and shorter baseball players are usually longer-lived (Samaras et al., 2002, 2003). The laboratory animals more phylogenetically related to human and, actually, the caloric restriction has been tested in rhesus monkeys. Unfortunately, data from these experiments are unclear. Two laboratories have concomitantly performed two large investigations with different experimental protocols obtaining different results (Colman et al., 2014; Mattison et al., 2012). Translating caloric restriction results from animal studies to human studies is not straightforward. We will come back to this issue in the conclusion of this mini review.

BODY MASS INDEX AND MORTALITY

Caloric restriction experiments have established a solid relation between the energetic balance of an organism and its life span. In comparison, few are the experiments in animals where scientists have tried to investigate the relationship between the percentage of body fat and longevity. This is due to technical difficulties in measuring the

percentage of body fat in animals and also due to the absence of something equivalent to what is routinely used for humans: body mass index (BMI). The BMI, initially proposed by Adolphe Quetelet (Eknoyan, 2007), is defined as the individual's body mass divided by the square of his height, with the value universally being given in kg/m^2. It is a simple and easy-to-measure approach to estimate the percentage of body fat. Because of large anthropometric differences among individuals, however, BMI is quite imprecise in measuring the percentage of body fat.

In epidemiology, large data collections are used to study the relationship between all-cause mortality and anthropometric values. In the majority of these studies it is observable a U-shaped relationship between the two values: very low BMI values (extreme leanness) are associated with increase mortality and very high BMI values (extreme obesity) also are associated with increased mortality.

Naturally, many of these studies are based on anthropometric values measured few times or even only one time during the life span of an individual. What is important for the present discussion is the persistence of obesity or overweight during the entire life span, which until now has not been easy to monitor in large cohorts. Some studies, for example, have observed that the presence of overweight in childhood and adolescence increases the risk of being obese in adulthood, with the major risk being represented by overweight in later adolescence (Must, 1996; Guo et al., 1994; Ferraro et al., 2003).

Going back to the BMI − mortality relationship, it is clear that BMI value at the lowest inflection point in this curve would indicate the optimal weight range for each individual, and we would expect this point to lay somewhere in the "normal weight" of the BMI category (from 18.5 to 25 kg/m^2). A recent meta-analysis by Flegal and colleagues that has analysed eight different large epidemiological studies, however, challenges this expectation (Flegal et al., 2014). These studies have calculated hazard ration using more specific BMI categories than the ones proposed by the World Health Organization and the American National Heart, Lung, and Blood Institute. The standard categories are the following: Underweight, Normal Weight, Overweight and Obesity (see Table 1 for BMI cut-offs). In the study by Flegal and colleagues, the categories used are the following: Underweight, Low-, Mid-, and High-Normal Weight, Low and High Overweight, and Obesity Grade 1 (see Table 1 for BMI cut-offs). Simply by the name chosen for the standard weight categories one would expect that the "Normal Weight" categories should represent a "healthier" state than the "overweight" categories. Instead, from the data of the meta-analysis the two categories with the lowest hazard ratio are the "High − Normal Weight" and the "Low Overweight". This is true for the entire male cohort, for the never-smokers male cohort and for the entire female cohort. Instead, for the never smoker woman cohort, the two categories with the lowest hazard ratio are "Mid- Normal Weight" and "High- Normal Weight". The question is: "are these, after all, respectively for gender and smoking status, the healthiest categories?" Naturally, these data are also underlining the importance of life style habits. The difference observed in female between the never-smokers and the entire cohort, for example, underlines the importance of avoiding unhealthy behaviours. One could speculate that never smokers are more prone to make other life style choices capable

of carry additional but independent health benefits: e.g. healthier diet composition and more physical activity (see respectively Solon-Biet et al., 2014; Kokkinos et al., 2008).

CONCLUSIONS

If we try to summarize and translate in simple "take-home" messages the scientific evidences discussed in the two preceding paragraphs, we could say:

– Caloric restriction experiments in animals are suggesting that a possible way to increase human life span is the adoption of a diet with a substantial reduction in energy content from the regular diet where each individual eats as much as he or she desires.
– A recent epidemiological analysis is showing that the lowest mortality is found not with a BMI value in the "Mid- Normal Weight" range but instead with a BMI more at the boundary between the "High- Normal Weight" and "Low Overweight" categories.

Is it possible to reconcile these two statements? Although interesting analyses have been published (e.g. Fontana & Hu, 2014; Bozorgmanesh et al., 2014) we, at present, probably lack enough evidence that could help us solve this conundrum. For caloric restriction, for example, it is important to understand if *ad libitum* (freely) fed animals are indeed in a normal state (e.g., for mice see Austad & Kristan, 2003). Can these unrestricted control animals be considered representative of the majority of human population, which is, of course, usually free to eat as much as desired? To answer this question we will need to pursue more investigations on fatness of control animals and on its role on life span. Laboratory animals, especially rodents which have been largely used in caloric restriction experiments, are routinely keep in constant presence of food and water similarly to what we do for some caged house pets, for example birds or hamsters. Some have argued that this condition is unhealthy and "obesogenic" and should not be used to represent the majority of humans (e.g. Martin et al., 2010).

BMI is a rather crude estimate for the percentage of body fat and is influenced, aside from energy intake, by factors unrelated to diet: physical activity level, gender, age, health status, smoking status, etc. The classical BMI categories seem to be too broad to distinguish sub-populations with different health risks. There is a need for additional studies and, ideally, for a consensus statement by the experts that will redefine the BMI cut-offs. BMI categories will also need to be specific for sex, age and ethnic groups. In fact, discussions on these points are ongoing (e.g. Friedman, 2014; Stevens, 2014).

As mentioned above, caloric restriction experiments on rhesus monkeys have given mixed answers (Colman et al., 2014; Mattison et al., 2012). In one study, the calorically restricted monkey had a clear life span benefit while in the other there was no statistically significant difference. One possible explanation can be found in how the restricted diet was planned. The study that did show a benefit was comparing *ad libitum* monkeys with monkeys receiving a 30% restriction of their *ad libitum* consumption. The study

that did not show the caloric restriction benefit used, as controls, monkeys that were partially restricted (around a 10 % restriction in comparison to *ad libitum* feeding) to avoid adult obesity. The experimental group of monkeys, in addition, received a 30% reduction from this obesity-preventing diet. The differences between the two studies included also a difference in diet composition but we can already predict that the different restriction protocols could very well have a repercussion on body composition, and they actually did. A deeper focus on body composition is necessary both for the basic science of caloric restriction and for large epidemiological studies that will help to clarify how to translate these mixed results to human-based situations. For a more in-depth discussion on these studies, see also Lorenzini, 2014.

Our society is fascinated by tall persons. Therefore, parents are usually happy if their child or adolescent is in the upper percentiles regarding stature. When correct nutrition is provided, the growth and development should unfold to their full potential. On average, being taller also means being heavier but parents of tall children should not worry unless the paediatrician says so. From the evidence reviewed so far, on the other end, we can at least conclude by reassuring the parents of children or adolescents that are in the lower half of the percentiles for weight or stature, or both, in comparison to their peers. Unless the child is at a percentile, so low that the chance for serious pathologies or for dwarfism must be considered, the parents should not worry. They should not be concerned about how to teach them to eat all the food in their dish, about how to modify their diet to improve their appetite, or about what the paediatrician may prescribe to improve their growth. These parents should instead be invited to consider that a lighter and a shorter child would have smaller chances to become an obese adult as well as more chances to have a longer and healthier life.

Table 1: Standard BMI categories and categories used in the study by Flegal et al., 2014.

Standard BMI categories	**Categories used in the study by Flegal et al., 2014**
less than 18.5: **Underweight**	15.0–18.4 **Underweight**
18.5–24.9: **Normal Weight**	18.5–19.9 **Low- Normal Weight**
	20.0–22.4 **Mid- Normal Weight**
	22.5–24.9 **High- Normal Weight**
25.0–29.9: **Overweight**	25.0–27.4 **Low Overweight**
	27.5–29.9 **High Overweight**
30.0 or more: **Obesity**	30.0–34.9 **Obesity Grade 1**

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THE ROLE OF DYNAMIC SYSTEMS IN MOTOR DEVELOPMENT RESEARCH: JUST A METAPHOR OR A NOTABLE REALITY?*

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ABSTRACT

In the present article an application of a new theory of motor control in the context of motor development theories and research has been discussed. In a brief overview of traditional theories of motor development a neuro-maturational theory is mentioned along with the two prominent proponents − McGraw & Gesell. Bernstein's fundamental insights in motor control were emphasized, such as the concepts of degrees of freedom and synergies, along with his contribution to the measurement technology and quantification. Basic principles of dynamic systems theory and common concepts such as self-organization, patterns, attractors or non-equilibrium systems are briefly described.

In the main part, an example of research in motor development carried out in dynamical perspective was introduced. The chosen example was the body of the research performed by Thelen et al. (1982, 1984, 1990) on a newborn's stepping. The distinction between the maturational perspective in which all the sequences of motor development are the result of maturation of nervous system, and the dynamic perspective in which development is seen as a mutual interaction between a number of body systems, including neural and muscular systems, which continuously affect the movement although none of them dominate (Kamm et al., 1990) has been made.

Keywords: *motor development, self-organization, patterns, motor control.*

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VLOGA DINAMIČNIH SISTEMOV V RAZISKAVAH GIBALNEGA RAZVOJA: SAMO METAFORA ALI POMEMBNA REALNOST?

IZVLEČEK

V aktualnem članku se razpravlja o aplikaciji nove teorije kontrole gibanja v kontekstu teorij in raziskav gibalnega razvoja. V kratkem pregledu tradicionalnih teorij gibalnega razvoja je teorija maturacije živčnega sistema omenjena skupaj z dvema znanima avtorjema – McGrawom in Gesllom. Poudarjen je Bernsteinov temeljni vpogled v kontrolo gibanja, kot so koncepti stopenj prostosti in sinergij, skupaj z njegovim doprinosom tehnologiji meritev in kvantifikaciji. Na kratko so opisani osnovni principi teorije dinamičnih sistemov in splošni koncepti, kot so samoorganizacija, vzorci, atraktorji in neravnotežni sistemi. V glavnem delu je predstavljen primer raziskave na področju gibalnega razvoja, izvedene v dinamični perspektivi. Izbrani primer so bile raziskave E. Thelen in sodelavcev (1982, 1984, 1990) na korakanju novorojenčkov. Opisana je razlika med maturacijsko perspektivo, v kateri so vse sekvence gibalnega razvoja rezultat zorenja živčnega sistema, in dinamičnim pogledom, v katerem je razvoj prikazan kot vzajemna interakcija med številnimi telesnimi sistemi, vključno z živčnim in mišičnim sistemom, ki kontinuirano vplivajo na gibanje, čeprav nobeden od njiju ne prevladuje (Kamm et al., 1990).

Ključne besede: *gibalni razvoj, samoorganizacija, vzorci, kontrola gibanja*

TRADITIONAL VIEW OF MOTOR DEVELOPMENT

Clark & Whittall (1989) in their historical overview of the field of motor development mention that the earliest studies in motor development had begun in the18th century but according to the most textbooks on motor development (e.g. Gabbard, 2000; Payne & Isaacs, 2001; Haywood & Getchell, 2001) the first relevant theories derive from a body of research performed by Arnold Gesell and Myrtle McGraw in 1930s and 1940s.

Gesell (as cited in Gabbard, 2000) based his theory on a belief that the development is the result of inherited factors and that no requirements or stimulation from the environment are needed. In his view, ordered genetic sequences exist, and they determine the growth of tissue and body structures but also behavior, which means that movements are the product of changes in neural formations.

Similarly, McGraw (1943, as cited in Haywood & Getchell, 2001) related changes in the motor behavior to the development of nervous system. For example, McGraw

associated an infant's ability to lift the head to the newly established control of the cervical region (Kamm et al., 1990).

The heritage left by the maturationists, which is still in use, consists of the developmental norms or the milestones which a child has to attain in his or her motor development.

After the neural maturational perspective, some other theories appeared on the scientific scene, among the latest were information processing and ecological perspectives. A common aim in many motor development studies, disregarding the theoretical perspective was the understanding of the relationships between the neural structure and behaviour, which in this case means the acquisition of motor skills. It is the skill that can be considered "a central dogma for kinesiology" as well, since the famous lecture by McCloy (1940) up to the present time (Zelaznik & Harper, 2007; Clark, 1995).

DEVELOPMENTAL BIODYNAMICS

The development of the motor skills (e.g. changes in motor behavior) was also central to the new developmental paradigm that arrived on the scene, the theory in which the development is seen as a mutual interaction between a number of body systems, including neural and muscular systems, which continuously affect the movement although none of them dominate (Kamm et al., 1990). The new perspective, called by some theorists „developmental biodynamics", was grounded on the dynamic systems theory which had already influenced many disciplines and had made an impact on the research concepts in chemistry, biology, but also in social sciences.

Although the system thinking in the developmental sciences, or broader − in biology, has a long tradition (Waddington, 1957), the real conceptualization and research has been possible since the legacy of the Nicolai Aleksandrovich Bernstein was introduced to the western science in the late 1960s.

Bernstein was a Soviet physiologist who studied human movement and wondered how the human movement system which is composed of such a large number of components (in Bernstein's words – 10^2joints, 10^3 muscles and 10^{14} neurons) could control multiple degrees of freedom in producing skilled actions (Bernstein, 1967). Bernstein proposed that the motor system is organized by a formation of synergies, e.g. units defined over the motor apparatus that automatically adjusts to each other and to the changing field of external forces (Gelfand et al., 1971) or, explained more directly, related to the movement, synergy refers to the "muscle linkage or coordinative structure, defined as a group of muscles often spanning several joints that is constrained to act as a single functional unit" (Tuller et al., 1982, p. 253). Bernstein rejected the idea of one-to-one relations between the neural codes and the produced movement patterns and he assumed that the movements can come out of different muscle contraction patterns and, similarly, that certain muscle contraction pattern does not have to produce identical movements every time. He believed that while the body moves, different forces arise

(e.g. centripetal and inertial) and gravity should also be taken into account. Thus, while the movement happens, the field of forces continually changes and the same muscle contractions may have different outcomes.

Besides developing the theory, Bernstein also enhanced the research in motor control, and therefore the motor development research as well, by introducing the new methods of movement quantification. Along with the new theoretical concept he has put forward kinematic analysis which allowed spatial and temporal description of movement (a broader technical historical description of Bernstein's contribution to the measurement technology can be found in Medved, 2002). Together with the electromyography, kinematic data provided much better insight in movement organization than the traditional, solely neural explanation.

PRINCIPLES OF DYNAMIC SYSTEMS APPROACH

Human surrounding, animate and inanimate world is full of patterns which evolve over time but how the order is achieved from such a complexity or, in other words, how the patterns are formed is not entirely understood. The dynamic systems perspective offers a view in which human behavior is governed by the generic processes of *self-organization*, which is the spontaneous formation of patterns and their change in the open, non-equilibrium systems (Kelso, 1995). That refers to the systems which are far from (thermal) equilibrium and exchanging energy, matter or information with their environment, and which cannot sustain without those sources. Self-organization can be found in numerous physical, chemical or biological systems but also in the inanimate world. A very suitable example for this particular article is the human brain which is in the context of self-organization as explained by Haken "the most complex system we know in the world. It is composed of up to 100 billion neurons (and Glia cells) which are strongly interconnected. For instance, a single neuron can have more than 10,000 connections to other neurons. The central question is: who or what steers the numerous neurons so that they can produce macroscopic phenomena such as the coherent steering of muscles in locomotion, grasping, vision i.e. in the particular pattern recognition, decision making etc." (2008, p. 2555). A description of the collective or coordinated behavior of complex systems, living things among them, requires rather abstract variables and physical-mathematical notions, such as *collective variables* (sometimes called *order parameters*), *attractor, stability, phase space* and so on. Avoiding technical jargon and equations of motion which are in the heart of the dynamical systems theory, a brief description related to motor behavior will be given.

Collective variables define coupling or coordinated behavior of a complex system. In the case of walking, for example, someone could describe the system on the level of many individual components such as muscles, tendons, neural pathways, and metabolic processes. On that level of observation, a system can behave in an extremely complex fashion but if the cooperative behavior among the parts exists the system can

be described by alternating the cycles of swings and the stance of the feet (Thelen & Smith, 2006). Also, other collective variables like muscle firing or torque forces etc., are possible.

Attractor states are a further important property of self-organization. An attractor may be explained simply as a preferred state or a point in the phase space of the system. Open systems could exhibit almost an infinite number of patterns of behavior, but they usually tend to form only a few of them or even just one and when they settle in that pattern (a mode of behavior) they tend to stay in it. If they are perturbed, they tend to return back to that attractor. Again, walking could serve as a simple example. In the coupled alternative movement of walking, legs are in the so-called anti-phase or 180 degree out of phase relation. Other relations are also possible within a state space but people prefer the anti-phase relationship which is in that case an attractor of 180 degrees out of phase (Thelen & Smith, 2006).

Stability is one of the core concepts of motor control, i.e. technically related it is a system facility in accommodating perturbations (Newell & Corcos, 1993). However, when several attractors exist with different basins of attraction, what appears is *multi-stability*, a coexistence of several collective states for the same value of control parameter and an essential characteristic of biodynamics. When the control parameter changes smoothly, attractor also changes and at one critical point the attractor may change even qualitatively (Kelso, 1995). In physics this phenomenon is called *non-equilibrium phase transition*. Another important idea for the movement organization is that movement is *softly assembled*, expressed for a fist time by Kugler & Turvey (1987), also grounded on Bernstein's premise that motor actions have to be programmed on a very high abstract level, otherwise the control of many parts acting on local level along with their interactions and continually changing forces may prove to be overwhelming for CNS. Softly-assembled, indicates that parts which are included in motor action should be organized in regard to their properties, interactions and context (Turvey, 1990). In other words, neuroanatomical components are selected naturally in a way that their organization is adaptive, flexible, task specific and that (soft) assembly may quickly reorganize itself according to the changes in task demands.

DYNAMIC SYSTEMS THEORY IN DEVELOPMENTAL RESEARCH

One of the most prominent examples of the use of the dynamic systems paradigm in motor development is the work of Ester Thelen on newborns' stepping (Thelen & Fisher, 1982; Thelen et al., 1984; Kamm et al.,1990). The behavior emerges when an infant is held upright and slightly leaning forward with his or her feet touching the ground. In this position, an infant performs alternating leg movements in a manner similar to walking. In the view of neural maturation and reflex-based theories, that behavior was considered a primitive reflex which disappears after 4 to 6 weeks as a consequence of brain maturation.

Thelen and colleagues (1982, 1984) compared the stepping and kicking of infants using kinematics and EMG, and what they found was a remarkable similarity in the number of measures between these two patterns. EMG records showed phasic activation of tibialis anterior and rectus femoris in flexion while extension was passive. Temporal organization of movement was also very similar and the authors concluded that stepping and kicking in infants is isomorphic. Significantly, they also found some differences − a range of motions for kicking was greater than for stepping and during supine kicking and the hip extension was longer with smaller extensions. The differences were explained by the changes in biomechanics of the movement with the changes in posture related to gravity. Lying supine, infants' hip flexion is assisted by gravity when the thigh passes the 90 degree angle, and when it is held upright, gravity assists the extension during the entire movement. Authors concluded that external forces were modelling and shaping spontaneous leg movement. They also assumed that the weight gain caused a decrease in the number of steps produced by infants thus suggesting that the gain of strength is slower than the gain of weight which inhibited walking. Additionally, Thelen et al. (1984) manipulated weight in two ways, first by adding the small weights to the infants' legs − which suppressed stepping, and second, by submerging the legs in warm water until their feet touched the bottom − which increased stepping dramatically.

The hypothesis was that the "disappearing" reflex could arise not by a design present in the brain but by the interdependence of heavy legs and biomechanically demanding posture (Thelen, 1995), manipulations with mass "restored" or "inhibited" reflex.

In the above example body weight and composition were in the role of the control parameter which can cause disappearance of a newborn's stepping response. The growth of the tissue affected the system and caused a qualitative shift in behavior. The way behavior changed suggests the effect of *non-linearity* – even a small change in the control parameter at a critical value may cause a qualitative shift (Thelen,1995).

In the study of the infants' kicking movements, Thelen et al. (1984) emphasized that none of the contributing factor to the behavior (e.g. the arousal of the infant, the gravity, neuromuscular system) has an advantage over the systems in determining the description of the kick. Gravity contributed to the topology, torques varied with gravity and vigour, and adapts to each change, while the whole system varied with arousal. The coordination and the timing in the kicking movements were the emergent properties, which were not specified by the neural signals alone. There was no program for the kick in any of the sub-systems, the behavior emerged as a product of interaction of the components concerned to the action. Thus, while the behavior was not specified than emergent, the system was *self-organized*.

Organisms in the development are complex because they are constituted of very many components, these components are in continuous interaction among themselves and with the environment which produces changes in components and in the system in whole. That effect is called the *multicausality*. Coherence among patterns of the emerged behavior is achieved by the interaction between organismic components and the constraints which has been set by environment and without a causal priority (Thelen

& Smith, 2006). One of the most important features of complex systems, i.e. patterns of behavior, is their index of stability. Crawling, for example, is a behavioral pattern which is very stable in his temporal and kinematic characteristics. Infants use that behavior for locomotion when a certain level of strength and coherence of the hands-to-knee posture is developed but the strength and the balance still do not allow upright locomotion (Thelen & Smith, 2006). Crawling remains stable for several months and then gives way to standing or upright walking which is the next stable behaviour, in that transition variability increases and system becomes unstable (Clark, 1995).

Crawling was also not pre-specified by genes or wired in nervous system (Thelen & Smith, 2006) but self-organized in task-context of moving through the space, and later replaced by an efficient locomotor pattern.

"Development can be envisioned as a series of evolving and dissolving patterns of varying dynamic stability, rather than an inevitable march toward maturity." (Thelen & Smith, 2006, p. 281).

CONCLUSION

Pioneer developmentalists were interested in infants' development of control over movements; namely, they assumed that the motor milestones and the emergence of motor skills reflect only brain maturation and a genetically driven overall development. The dynamic systems theory in motor control aims to explain the behavior of complex systems in the physical or biological sphere, and it could be comprehended as a conceptual guide, research program or a formal theory. From the dynamic systems perspective, the central nervous system is not exclusively responsible for movement, they are rather a product of biomechanical and energetic properties of the body, environment and specific demands of the task. The relations between the components are not hierarchical − top down, but rather non-linear, self-organizing and flexible. The research in dynamic perspective has undoubtedly managed to reveal the richness and the complexity of development as a multiple, mutual, and continuous interaction of all the levels of the developmental system (Thelen & Smith, 2006).

In the words of Ilya Prigogine (Arts Meets Science, 2013), a Nobel chemist (awarded in 1977 for his work in non-equilibrium thermodynamics which included self-organization) "... instead of emphasizing stability and permanence, science should emphasize change and adaptation ... non-equilibrium can produce coherence, structures and very complex patterns which permit us to see, to understand much better a type of structures that we see in the world around us".

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THE QUANTITY AND INTENSITY OF PHYSICAL ACTIVITY DURING PHYSICAL EDUCATION IN 3RD GRADE PRIMARY SCHOOL CHILDREN*

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ABSTRACT

Introduction: The purpose of this study was to establish the effective time parameters of physical education (PE) lessons and the amount of time that children spent in moderate to vigorous physical activity (MVPA).

Methods: The study involved a total of 189 third-grade pupils (94 boys and 95 girls), aged 8 to 9 years, from five primary schools in the Slovenian coastal region. We used an accelerometer in each school to measure the quantity and intensity of activity during three PE lessons led by the class teacher and / or PE teachers.

Results: We found that the average duration of a PE lesson was 36.6 ± 7.7 minutes: lesson preparation time 14.9 ± 7.7 minutes, the main activity 19.3 ± 7.1 minutes and the conclusion 1.8 ± 2.4 minutes. Time spent in MVPA was 13.2 ± 4.1 minutes, with no statistical differences between genders (P = 0.338). An average PE lesson carried outdoor on the outside playground lasted an average 7 minutes less than lesson in the gym (P = 0.066), and the average PE lesson's effective time was shorter by 1.5 minutes as well (P = 0.011). The children led by both teachers together showed, on average, that their MVPA had been shortened by 3.5 minutes. There were no statistical differences between a PE teacher and a classroom teacher. Furthermore, it was revealed that the time spent in MVPA tends to decrease proportionally with the increase in the number of children participating actively in the PE lesson (r = -.12; P = 0.092).

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Conclusions: The research only included the time spent in MVPA during PE lessons and not their content. However, it can be concluded that everyday PE lessons could extend the time spent in MVPA by 6 % a week.

Keywords: *physical/sports activity, effective time, children, accelerometer.*

KOLIČINA IN INTENZIVNOST GIBANJA MED URO ŠPORTA V 3. RAZREDU OSNOVNE ŠOLE

IZVLEČEK

Uvod: Cilj prispevka je bil ugotoviti efektivni čas ure Športa in čas, ki so ga otroci preživeli v srednji in visoki intenzivnosti (MVPA).

Metode: V celotno raziskavo je bilo vključenih 189 tretješolcev (94 dečkov in 95 deklic), starih 8–9 let iz petih naključno izbranih obalnih osnovnih šol. Na vsaki šoli smo z merilnikom pospeška izmerili količino in intenzivnost gibanja treh ur Športa, ki so jih vodile razredne učiteljice in/ali športni pedagogi.

Rezultati: Ugotovili smo, da povprečni čas ure Športa znaša 36,6 ± 7,7 minut, od tega je pripravljalni del 14,9 ± 7,7 minut, glavni del 19,3 ± 7,1 minut in zaključni del 1,8 ± 2,4 minute. Čas v MVPA znaša 13,2 ± 4,1 minut brez razlik med spoloma (P = 0.338). Ura Športa, izvedena na zunanjem igrišču, je trajala v povprečju 7 minut manj kot v telovadnici (P = 0.066) pa tudi čas MVPA je bil krajši za 1,5 minute (P = 0.011). Otroci, ki so jih vodili učitelj in športni pedagog hkrati, so dosegli povprečno 3,5 minut krajši čas MVPA, medtem ko med vodenjem zgolj učitelja in vodenjem zgolj športnega pedagoga ni razlik. Poleg tega smo ugotovili tudi, da je trend časa MVPA krajši z naraščanjem števila aktivno sodelujočih otrok pri uri Športa (r = –.12; P = 0.092).

Zaključki: V raziskavi smo opazovali le čas MVPA pri uri Športa, ne pa tudi njene vsebine. Zaključimo lahko, da bi vsakodnevna ura Športa podaljšala tedenski čas MVPA za 6 %.

Ključne besede: *gibalna/športna aktivnost, efektivni čas, otroci, merilnik pospeška*

INTRODUCTION

Our modern lifestyle is becoming increasingly sedentary in both adults and children. Children, due to physical inactivity and inadequate nutrition, are now being exposed to an increased risk for the occurrence of various diseases, such as cardiovascular disease, type 2 diabetes, high blood pressure, stroke and other diseases later on life (Cepanec, 2013). Slovenian children, aged 8–5, spend 32−51 minutes on MVPA, depending on gender and age (Volmut et al., 2012). Worldwide trends confirm the Slovenian results and suggest that MVPA is decreasing even further, with the children's age (Biddle et al., 2004; Robberts et al., 2004). Therefore, most children do not meet the minimal MPVPA standards.

Such children are under the close supervision of many researchers that are currently trying to develop an adequate method of intervention in order to increase their physical activity levels and diminish their levels of inactivity. Several META analyses of vast scientific data have been performed to identify the most suitable methods of intervention. Interestingly, one of the aims to assure a daily physical education class (Basset et al., 2012). Basset et al. (2012) identified that each PE class could potentially contribute the amount of 23 minutes of MVPA, almost a third of the minimal standards. However, other authors came to different conclusions. Štemberger et al. (2005), performed a study in Slovenian children and found only 9 minutes of MVPA during one PE class.

For some children, PE is the only form of physical/sport activity they receive, as they also choose to do other activities, which are not physical in nature. That is why PE is very important for them. In Slovenia, the first and the second school triad place PE on the school curriculum three times a week and twice in the third. If children choose the optional sports program, carried out by some elementary schools then PE classes are carried out five times a week. Therefore, we still face the challenge of increasing the frequency of PE lessons. However, here we have aimed to measure the quantity and the intensity of MVPA that third graders receive during a PE lesson.

METHODS

Children

In total 189 of the 3rd grade children (94 boys; aged 8–9 years) from 5 randomly selected primary schools from the Slovenian coastal region were recruited for the study. We explained all the details to the schools' principals, the physical education teachers and the parents. The motivation for the study was presented in such way that physical education teachers were not motivated to influence the study results. Children's parents gave written consents before the research was conducted onset.

Research design and instruments

In every school we measured physical activity phenotypes during three physical education classes that were led by educators and/or physical education teachers. Physical activity was monitored by accelerometers (Actigraphy GT1M, Actilife, USA) that were worn on the children's hips for the whole duration of the physical education class. Five minutes prior to and after the classes the accelerometers were attached and removed from the children, respectively. Children, not the teachers, did not know the real purpose of the accelerometers in order to assure a blind study design.

Data processing and statistics

Accelerometer data were downloaded onto the PC with a 15-second epoch applied. To distinguish between physical activity phenotypes, we took into consideration the threshold values proposed by Mahmutović and Volmut (2012).

- Physical inactivity: < 134 counts per 15 seconds,
- Light physical activtiy: 135–633 counts per 15 seconds,
- Moderate physical activtiy: 634–1853 counts per 15 seconds,
- Vigorous physical activtiy: > 1853 counts per 15sseconds,
- MVPA – the effective time of physical education: the time spent in moderate and vigorous physical activity.

The data were processed with the SPSS statistical package (Chicago IL, USA). After the data normality was confirmed all data were presented with mean standard deviation. We applied a one-sample t-test to check the differences from the expected value: A one-way ANOVA was used to check the differences between teachers (educators, physical education teachers, both). Pearson correlation was used to correlate the effective time with the number of the participating children. All statistical decisions were considered at $p < 0.05$.

Results

We have found out that the time children spent in MVPA during physical education was 13.2 ± 4.1 minutes (Figure 1), in boys 13.5 ± 4.3 minutes, and in girls 12.9 ± 4.0 minutes, with no gender differences (P = 0.338). The average time of physical education was 36.6 ± 7.7 minutes, from where the introductory part was 14.9 ± 7.7 minutes, the main part 19.3 ± 7.1 minutes and the final part 1.8 ± 2.4 minutes (Figure 2). When physical education classes were carried out outside, they lasted 7 minutes less than inside (P = 0.066) (Figure 3) with MVPA being shorter for 1.5 minute (P = 0.011). Interestingly, we also confirmed a significant teacher effect (P = 0.001), where the lowest MVPA (-3.5 minutes) was found if both the educator and the teacher conducted the physical education class together (P = 0.005). However, there were no differences

between the educator and the physical education teacher. Finally, we detected a trend towards a negative correlation between the time spent in MVPA and the number of children participating in the class (r = -0.12, P = 0.092).

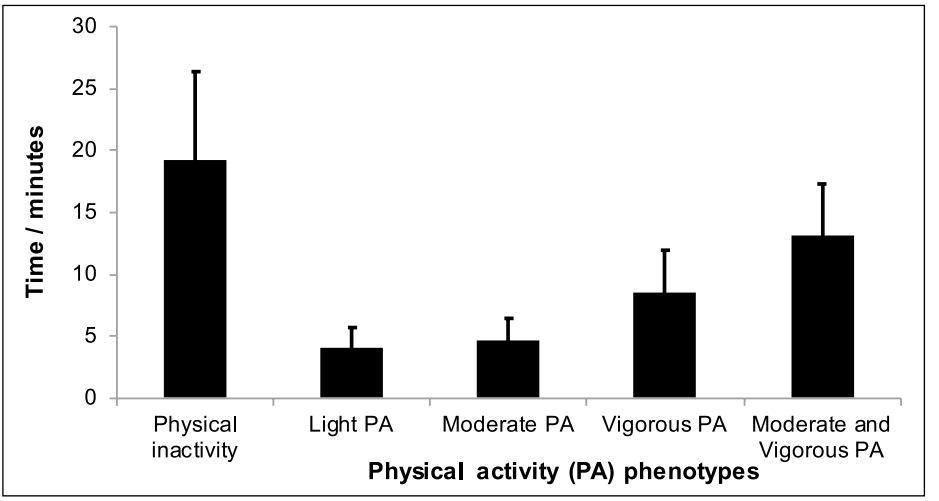

Figure 1: Time spent in physical activity phenotypes during Physical education

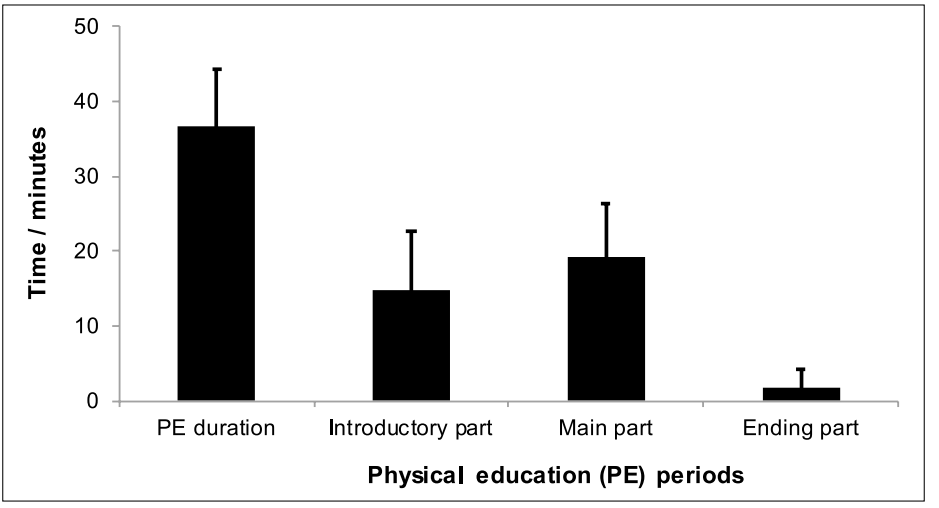

Figure 2: Time spent at Physical education class with the breakup of time spent in different periods of physical education.

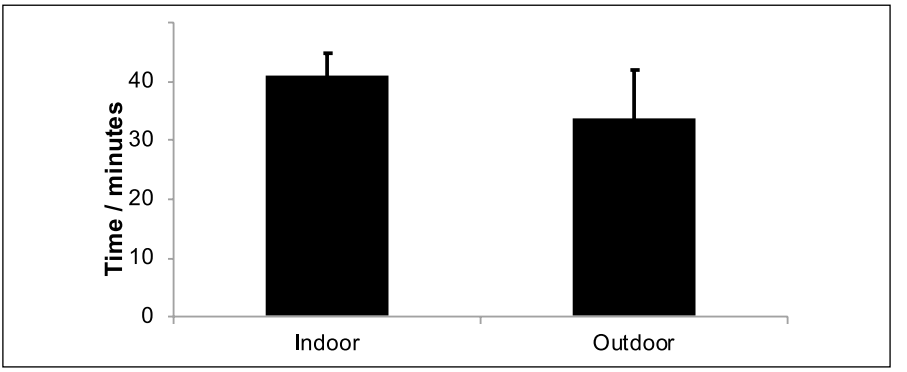

Figure 3: Difference between the time spent at Physical education when performed indoor and outdoor (P = 0.066)

Discussion

World Health Organization (2010) recommends at least 420 minutes of MVPA per week. Although Biddle et al. (2004) and Roberts et al. (2004) report that children do not meet the minimal standards from MVPA, the PE class remains an important moment to assure the required physical activity of adequate intensity (Basset et al., 2012; Štemberger et al., 2005).

We have established that PE is currently covering 9.3 % of weekly recommendations. If children had PE five times a week (every day) for one lesson (45 minutes), they would be in an appropriate MVPA for 65 minutes, so MVPA would increase by 6 % on a weekly basis (15.3 % of weekly recommendations). If children had four PE lessons per week placed in two joint PE lessons, which means that PE would occur twice a week for 90 minutes, they would be in a MVPA for 55.8 minutes, so MVPA would increase by 4 % on a weekly basis (13.3 % of weekly recommendations) because in one PE lesson (45 minutes) children spend 14.4 minutes in MVPA and in two joint PE lessons (90 minutes) they spend 27.9 minutes (Wang, Pereira and Mota, 2005). If an average effective time that Fairclough and Stratton state in their study (2006) was up to 50 % of a total PE lesson, then PE would fulfil about 21 % of weekly recommendations. The introduction of two joint PE lessons raises the question of whether the students of class level would be able to participate so long in a MVPA since tiredness and a lack of motivation could lead to injuries or a false learning of motor tasks. Therefore, we believe that it would be unreasonable to increase the number of PE lessons per week.

We have found out that children spend 13.2 ± 4.1 minutes in MVPA during physical education. Štemberger's study (2005) shows that the average MVPA time, measured with a stopwatch, is 9 minutes. Fairclough and Stratton's study (2006) shows that the average time in MVPA of various studies, carried out by direct observation or acceler-

ometers, was 37.4 % ± 15.7 % of a total PE lesson (16.8 minutes on average in one PE lesson), but with measuring effective time with a heart rate monitor this time increased and reached 49.1 % ± 20.5 % of a total PE lesson (which is 22.1 minutes on average in one PE lesson). This means that the result may vary depending on the measurement instrument. In one Texas school children had a lower value because they only spent 3.8 minutes on average for MVPA (Simons-Morton, Taylor, Snider and Huang, 1993).

We have calculated that an average MVPA time for boys was 13.5 ± 4.3 minutes, and for girls 12.9 ± 4.0 minutes. We have found out that there were no gender differences. Štemberger's study (2005) shows that no statistically significant differences between boys and girls were established. Even in Fairclough and Stratton's study (2006) it was confirmed that only four of thirteen examined studies detected statistical difference between genders.

We have noticed that educators or other teachers who had conducted lessons before PE did not want to finish their lessons earlier so that children could start with their sports lesson in time. Many times their lessons were extended by a few minutes. In addition, physical education teachers must finish PE lesson a few minutes earlier so that children have enough time to change and prepare for the next lesson. In this way, educators and PE teachers are left with less time to perform lessons. Thus, an average time of PE in the gymnasium lasts for 36.6 minutes and on the outside playground on average for 7 minutes less. In Štemberger's study (2005) it was measured that an average time of a total PE teaching lesson lasted for 34 minutes.

PE lesson was divided into three parts, namely, the preparatory part, which on average lasted for 14.85 minutes, the main part which on average lasted for 19.3 minutes and the final part, which lasted for only 1.8 minute. In Štemberger's study (2005) it was calculated that the preparatory part on average lasted for 10 minutes, the main part for 20 minutes and the final part for 4 minutes.

In addition, with the increase in the number of actively participating children, the time in MVPA decreases, so it is important that classes do not have too many pupils. Therefore, educators (most of which are independently leading PE lessons and have to control more than 25 children) prioritize the safety of children. In addition, they have to prepare all the tools and props that they need during each lesson. The loss of time due to prop set up could be solved in such a way that students who come first set up the room and students who finish last put the props away. In between the lessons, the educator or physical education teacher would only slightly adjust the training environment and sport props for every age group. Even foreign studies indicate that students in classes with more than 45 pupils are more than 50 % less physically active in sport than students from smaller classes. (Center to Eliminate Health Disparities and Samuels and Associates, 2007; Failing Fitness).

CONCLUSION

The results of our study indicate the following:

- an average net time of PE in the 3rd grade primary school children lasts 36.6 ± 7.7 minutes and on the outside playground on average 7 minutes less,
- children spend only 13.2 ± 4.1 minutes in MVPA during the 45 minutes of physical education, with no gender differences,
- the MVPA achieved during PE covers only 9.3 % of weekly recommendations, which makes the strategies of increasing PE weekly hours doubtful.

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CAFFEINE INTAKE ENHANCES ENDURANCE PERFORMANCE IN SUB-ELITE BUT NOT IN ELITE ATHLETES*

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ABSTRACT

The aim of our contribution is to evaluate the influence of caffeine (CAF) ingestion on maximal power output (MPO) during endurance performance. Two groups of men – 10 sub-elite cyclists and 8 elite cyclists completed a randomized, crossover, double-blind study. Over the course of three days participants completed three identical experimental tests (60min cycling time trial on 70 % VO_{2max} followed by test to exhaustion). Three experimental meals − a combination of 500ml water, a gel supplement and a specific dose of CAF: a placebo (PLA, no caffeine), CAF2 (2 mg / kg body weight (BW)) and CAF7 (7 mg / kg BW) were administered 45min prior to the start of the experimental tests. Subjective RPE values were determined using the Borg 20-category scale. The results show significant differences between MPO_{PLA} and MPO_{CAF7} and between MPO_{CAF2} and MPO_{CAF7} with $p = 0.018$ and $p = 0.019$, respectively, in the sub-elite cyclists group only. The mean MPO during experimental test in sub-elite cyclists, but not in elite cyclists, was significantly enhanced following caffeine ingestion ($p = 0.05$). These findings indicate that caffeine intake at recommended levels is not associated with improved performance in a professional level cyclist. The results of the comparison of the experimental situations using the Borg scale are not persuasive. We found a significant difference *(0.008356) between the PLA and CAF2 experimental measurements ($p < 0.05$). The level of substantive significance was assessed using Cohen's coefficient effect and only a small "size of effect" (0.19) was found. It is therefore not possible to determine whether the Borg scale might be used to define the effects of caffeine ingestion on endurance performance, due to the multifactorial effects of caffeine.*

Keywords: *caffeine, maximal power output, aerobic exercise, cycling*

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UŽIVANJE KOFEINA POVEČUJE VZDRŽLJIVOST PRI NEVRHUNSKIH ŠPORTNIKIH, NE PA PRI VRHUNSKIH

IZVLEČEK

Namen našega prispevka je oceniti vpliv zaužitega kofeina na maksimalno moč (MPO) v času vzdržljivostne vadbe. Na dveh skupinah, desetih nevrhunskih kolesarjev in osmih vrhunskih kolesarjev, je bila izpeljana randomizirana, navzkrižna, dvojna slepa študija. V treh dneh so udeleženci zaključili tri enake eksperimentalne teste (60 minut kolesarskega kronometra na 70 % VO_{2max}, čemur je sledil preizkus izčrpanosti). Tri vrste eksperimentalnih obrokov − kombinacija 500 ml vode, dodatek gela in določen odmerek kofeina − so bile razdeljene med udeležence 45 minut pred začetkom eksperimentalnih testov, in sicer: placebo − PLA (brez kofeina), CAF2 (2 mg/kg telesne mase) in CAF7 (7 mg/kg telesne mase). Posamezne vrednosti RPE so bile določene s pomočjo Borgove lestvice dvajsetih kategorij. Rezultati kažejo na pomembne razlike med MPO_{PLA} in MPO_{CAF7} ter med MPO_{CAF2} in $MPO_{CAF7,}$ kjer sta vrednosti $p = 0,018$ in $p = 0,019$ zgolj v skupini nevrhunskih kolesarjev. Povprečna vrednost maksimalne moči se je med poskusnim testom po zaužitju kofeina znatno povečala ($p = 0,05$) samo pri skupini nevrhunskih kolesarjev. Te ugotovitve kažejo, da zaužitje kofeina znotraj priporočenih količin ne vpliva na večjo vzdržljivost vrhunskih kolesarjev. Rezultati primerjave eksperimentalnih testov z uporabo Borgove lestvice pa niso prepričljivi. Pomembno razliko (0,008356) smo zaznali med eksperimentalnima meritevama PLA in CAF2 ($p < 0,05$). Stopnja odločilnega pomena je bila določena s pomočjo Cohenovega koeficienta učinka in je bila ocenjena le kot majhen "obseg učinka" (0,19). Zaradi multifaktorskih učinkov kofeina zato ni mogoče ugotoviti, ali bi se s pomočjo Borgove lestvice lahko opredelilo vpliv zaužitega kofeina na vzdržljivost.

Ključne besede: *kofein, maksimalna moč, aerobne vaje, kolesarjenje*

INTRODUCTION

It is evident that dietary supplements are becoming a part of an athlete's daily diet. The appropriate use and timing of dietary supplement intake may positively influence athletic performance and recovery. One of the most commonly used dietary supplements is caffeine (CAF). It is a natural component of many foods and beverages available to the general public. CAF is a stimulant that has a number of physiological and psychological effects. For this reason, it is widely used as a food supplement in the manufacture of sports nutrition. For many athletes, CAF is part of their dietary regime. Its application is found before or during competitions, and the training effect of CAF is dependent on its source, the adopted quantity dosage, one's sex, nutritional status and

other factors related to each individual (Magkos & Kavouras, 2004). The influence of CAF on the human body is studied in relation to the possible improvement in sports performance. The body has a number of effects associated with a direct influence on performance – the stimulation of the central nervous system; an increasing cAMP and an influence on the activity of adrenaline are associated with increased lipolysis in adipose and muscle tissue, thereby increasing the availability of energy substrates to working muscles (Burke & Deakin, 2002). This glycogen sparing potential is not the only mechanism explaining the ergogenic effect of CAF. There is evidence of an increase in performance after CAF without affecting the oxidation of nutrients. It has been recently demonstrated, that CAF ingestion (3 mg/kg BW) is a possible strategy to independently enhance the power output of muscle glycogen availability (Lane et al., 2013).

Contemporary protocols for CAF intake on the day of training or competition are based on recent evidence showing that low doses of CAF (1−3 mg/kg BW) are as equally effective as the traditionally used larger doses (6−9 mg/kg BW) (Ganio et. al, 2009; McNaughton et al., 2008).

Within the context of potential ergogenic effects, CAF was tested many times, and has already been administered to athletes in many different sources such as chewing gum (Ryan et al., 2013), sports gels, Coca Cola, capsules and coffee (Jenkins et al., 2008; Cureton et al., 2007; Cox et al., 2002; Conway et al., 2003; Graham, 2001; Ganio et al., 2009).

The evidence for an ergogenic effect of CAF on high-intensity performance is scant compared to the data retrieved with endurance tasks. From a practical point of view, it must be noted, however, that the majority of performance-enhancing findings was generally verified in recreationally trained males. Whether the findings could be extrapolated to the elite athletes, remains unknown. Moreover, it is necessary that all evidence-based, though theoretical proposals and conclusions are clearly translated into the real training and / or competition practise. Therefore, the aim of our study is to find the variance between the two groups of athletes, each with a different training − fitness status.

MATERIALS AND METHODS

The research was precisely designed with respect to the CAF-supplement scientific trials. Ten male sub-elite cyclists and eight male elite cyclists (Table 1) completed the randomized, crossover, double-blind study. The sample group was divided into a sub-elite category and an elite category, according to the training volume (km per year, training hours per week) and the corresponding fitness status (VO_{2max}). The subjects were not allowed to participate in the study if they were smokers, took medications that might affect physical performance or metabolism, or lacked the ability to perform the initial laboratory maximal oxygen consumption tests (VO_{2max}). Before giving their written informed consent, every accepted participant became familiar with the possible

negative consequences of all the procedures. The study was reviewed and approved by the Ethics Committee of the Faculty of Sports Studies.

Table 1: Characteristics of the elite and the sub-elite cyclists (Mean ± SD, range).

Parameters		sub-elite cyclists (n = 10)		elite cyclist (n = 8)		p
		Mean ± SD	Range	Mean ± SD	Range	
Age (years)		27.7 ± 4.1	22 – 35	23.5 ± 5.6	18 − 35	0.13
Height (cm)		181.4 ± 7.9	168 – 191	183.4 ± 5.5	174 − 194	0.52
Body weight (kg)		77.6 ± 8.0	68 – 92	76.4 ± 9.0	63 − 89	0.79
VO_2max. (ml / kg)		56.9 ± 6.6	50 – 67	66.4 ± 8.7	59 − 79	**0.02**
BMI (kg / m2)		23.6 ± 1.5	22 – 28	22.7 ± 1.8	21 − 26	0.51
FFM (kg)		68 ± 6.8	61 – 82	67.7 ± 7.6	57 − 79	0.95
Training volume*	(km / year)	5000 − 7000		18 000 – 22 000		**0.00**
	h / week	10 − 15		30 − 35		**0.00**

*Legend: BMI − body mass index, FFM − fat free mass, *expressed in terms of mean volume of training over the last 3 years.*

THE DESIGN OF THE EXPERIMENT

The experimental measurements were preceded by the incremental cycling test of exhaustion. Maximal oxygen consumption tests (VO_{2max}) were undertaken one week before the first experimental trial. The maximal test was used to determine the power output corresponding to 70 % of each subject VO_{2max} to be used in the experimental trials. During the three non-consecutive experimental days (within 1 month) the participants completed three identical experimental trials (60 min drive at the 70 % of VO_{2max} intensity followed by a test of exhaustion). All tests were completed on a software-controlled bicycle ergometer (Lode Excalibur *Sport*) using cardio metabolic unit Cortex MetaLyzer3B.

Three experimental liquid meals (a combination of 500 ml water, a gel supplement and a specific dose of anhydrous form of CAF): placebo (PLA, no caffeine), CAF2 (2 mg/kg BW) and CAF7 (7 mg/kg BW) were administered 45min prior to the start of the experimental tests. Time and maximal power output (MPO [Watts]) during the ex-

haustion phase of the experimental trials were measured. Rating of perceived exertion (RPE) was determined during the measurements at a 2-minute interval using the Borg scale (6−20).

Each participant obtained an individually adjusted specific pre testing carbohydrate–rich dietary protocol (8 g/kg BW/day). The athletes were asked to follow the dietary regime on the day preceding the experimental trials in order to eliminate the possible detrimental effects of the experimental measuring (i.e. substantive muscle glycogen reduction). Finally, the participants were given instructions about CAF-containing food and beverages and were asked to abstain from CAF ingestion at least 72 hours before the experimental measuring. Eventually, the participants were asked to record the real food intake, to detect any possible dietary mistakes.

STATISTICAL ANALYSIS

The data obtained was statistically analysed with the NCSS 9 software (Hintze, 2013) and presented as mean, standard deviation (SD) and range (minimum and maximum values). To determine the differences in MPO a t-test was used. The level of significance was set at the $p < 0.05$ level. A multi-factor analysis of variance (ANOVA) was used to examine the interactions within the whole group and the main effects using the RPE as a covariate. The level of substantive significance ("size of effect") was assessed using Cohen's *d* effect coefficient.

RESULTS

Results show significant differences (Table 2) between MPO_{PLA} and MPO_{CAF7} and MPOCAF2 and MPOCAF7 in the sub-elite group, but not in the elite ($p < 0.05$). The level of substantive significance was assessed using the Cohen's coefficient effect and was found to be middle and small "size of effect" (0.43 and 0.29). There was no significant effect of specific doses of CAF on MPO in the group of elite cyclist (Table 2).

Table 2: Maximal power output during (MPO) experimental trials and statistical analysis of the experimental trials within sub-elite and elite groups (p).

		Maximal power output (W)		p		
Experiment	Sample group	Mean ± SD	Range	MPO_{PLA} vs MPO_{CAF2}	MPO_{PLA} vs MPO_{CAF7}	MPO_{CAF2} vs MPO_{CAF7}
PLA	sub-elite	361.1 ± 24.7	325–404	0.459	**0.018**	**0.019**
CAF2		365.2 ± 26.7	332–422			
CAF7		372.9 ± 28.4	338–421			
PLA	elite	432.4 ± 44.0	360–480	0.444	0.863	0.803
CAF2		437.4 ± 48.9	381–494			
CAF7		434.5 ± 64.1	287–500			

Legend: PLA, placebo; CAF2, caffeine dose 2mg/kg/body weight; CAF7, caffeine dose 7mg/kg/body weight; MPO, maximal power output (W).

The result of ANOVA detected a statistically significant difference, as confirmed by Fisher's post-hoc LSD test. A statistically significant difference was found between PLA and CAF7 (Table 3).

Table 3: Statistical analysis of the RPE using the Borg scale.

Caffeine dose	p
PLA vs CAF2	0.352124
CAF2 vs CAF7	0.086538
PLA vs CAF7	**0.008356**

Legend: RPE, rate of perceived exertion; PLA, placebo; CAF2, caffeine dose 2mg/kg/body weight; CAF7, caffeine dose 7mg/kg/body weight.

Additionally, the level of substantive significance ("size of effect") was assessed in the sub-elite group using Cohen's *d* effect coefficient which shows the relative change of the average variable with respect to the standard deviation of measurements in the

group. The difference between PLA and CAF7 situation is considered to be significant (Table 4).

Table 4: Statistical analysis of the RPE via the size of effect (sub-elite group).

	Cohen's *d*
PLA and CAF2	0.06
PLA and CAF7	**0.19**
CAF2 and CAF7	0.12

Legend: RPE, rate of perceived exertion; PLA, placebo; CAF2, caffeine dose 2mg / kg/body weight; CAF7, caffeine dose 7mg/kg/body weight.

DISCUSSION

Caffeine is a substance which is chronically integrated in sports dietary supplements. In 2004, CAF was erased from the list of banned substances, but currently it is still a substance listed as monitored (World Anti-Doping Agency, 2013).

There is ample evidence in the literature that CAF administered prior the exercise enhances performance (Cox et al., 2002; Ganio et al., 2009; Jenkins et al., 2008), however, the data where positive ergogenic effect of CAF dose on performance was not established is still available (Jacobson et al., 2001; Hunter et al., 2002). The contemporary research is dominantly carried out with sub-elite athletes. By incorporating a sub-group of elite (professional) athletes we tried to identify the possible superiority of dietary supplement intake in the context of various training statuses of the athletes. Therefore, we focused particularly on elite (professionally trained) athletes and made a comparison with sub-elite group**.** The overall size of the studied sample presented the limitation in the study. In particular, the number of elite-trained athletes willing to participate and mainly able to fully complete the experimental design was the main limitation. However, it must be noted that the number of professionally trained cyclists in the Czech Republic is rather small.

The primary aim of our specific research was to identify the variations in possible ergogenic effect of specific dose of CAF (0, 2 and 7 mg/kg BW) on MPO between sub-elite (well-trained) and elite (professionally trained) athletes. We chose a methodology that is standardized by a number of corresponding studies. Experimental cycling trial was performed ~ 60min after the oral CAF administration (Jenkins et al., 2008; Cureton et al., 2007; Cox et al., 2002).

The measured data (Table 2) demonstrate that the ingestion of CAF significantly increased MPO only in the sub-elite group (Table 3). The mean power output during the experimental test was enhanced following CAF ingestion (7 mg/kg BW) when compared with placebo (361.1 ± 24.7 vs. 372.9 ± 28.4 W, $p = 0.05$).

Furthermore, we found the dose response trend in sub-elite athletes. It must be noted that MPO was significantly enhanced both in CAF2 and CAF7 trial. It is assumed that the more CAF the well trained sub-elite (but not elite) athletes would ingest the better is their performance. However, a growing body of evidence currently suggests that moderate to low doses of CAF (~ 3 mg/kg BW) are effective at enhancing sport performance (Maughan, 2014).

Despite these facts we confirm the ergogenic influence of CAF intake on endurance performance consistently with the recent well-designed study of Lane et al. (2013), yet our findings are not consistent with several other recent studies. In the study of Ryan et al. (2012) the authors suggest that a low-dose CAF (200 mg) administered in chewing gum has no effect on cycling performance in recreational athletes (VO_{2max} 45.5 ± 5.7 ml/kg/min). Whether the form of CAF ingestion might modulate the performance outcome still remains to be established. In a study with well-trained athletes of similar fitness status (VO_{2max} 65.0 ± 6.3 ml/kg/min) and CAF ingestion (6 mg/kg BW) McNaughton et al. (2008) concluded that cycling performance was improved significantly.

There was no rationale for direct statistical comparison of sub-elite and elite group, since the main effect of CAF was only detected in the group of sub-elite cyclists.

Therefore, the training status (the general state of preparedness of an athlete, characterizing the current level of adaptation to the requirements of the relevant sports specialization – in our case, cycling performance) is assumed to be more important than the supplement of CAF. These findings indicate that CAF intake at both recommended (low) levels, i.e. 1−3 mg/kg BW and, moderate levels (6−9 mg / kg BW) previously thought to be ergogenic, is not associated with improved performance in professional level cyclist.

Finally, we focused on the possible effect of CAF intake on RPE. The results of the RPE analysis using the Borg scale are not convincing. Despite some differences between PLA and CAF7 experiments, there seems to be no rationale for using the Borg scale to differentiate the effects of various doses of CAF ingestion on endurance performance.

CONCLUSION

Despite the limited sample size we suggest that caffeine supplement represents a lower ergogenic benefit for professional (elite) athletes compared to the sub-elite.

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DIFFERENCES IN THE KNEE TORQUE BETWEEN HIGH- AND LOW-BAR BACK SQUAT TECHNIQUES: A PILOT STUDY

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ABSTRACT

Purpose: *The squat is one of the most frequently used exercises in sports training and competitions. There are several squat variations: i) the front squat (FS), ii) the high-bar back squat (HBS) and iii) the low-bar back squat (LBS). As the biomechanics of the LBS technique have been studied to a lesser extent, therefore the purpose of this pilot study was to analyze the differences in knee joint net muscle torque between the HBS and LBS.* ***Methods:*** *One healthy male subject (180.0 cm, 76.0 kg, 26 years) performed 10 steady paced squats (5 HBS and 5 LBS) with additional weight (40.4 kg) to a 90° knee angle. Kinematic and kinetic data were gathered using a high-speed camcorder and a force plate, respectively. The maximal and average knee joint net muscle torques (M_{max} and M_{avg}) were then calculated via 2-dimensional inverse dynamics.* ***Results:*** *A significantly greater M_{avg} was observed using the HBS technique as*

compared to the LBS, both during the entire range of the squat (M_{avgHBS} = 221.6 ± 5.1 Nm, M_{avgLBS} = 203.3 ± 10.2 Nm; p = 0.026) as well as during the eccentric (M_{avgHBS} = 226.0 ± 5.9 Nm, M_{avgLBS} = 202.0 ± 14.0 Nm; p = 0.043) and concentric (M_{avgHBS} = 216.2 ± 3.6 Nm, M_{avgLBS} = 205.0 ± 7.9 Nm; p = 0.021) phase separately. ***Conclusions:*** *It can be concluded that the lower M_{avg} during the LBS could be due to the load transfer to the hip joint, most likely because of the greater anterior tilt of the torso, which is a direct response to a lower and more posterior bar placement on the back to finally maintain an unchanged centre of mass. Confirmation of these findings in a larger sample would imply that the LBS could be a more appropriate squat technique when knee joint relief is desired.*

Keywords: *inverse dynamics, force, kinematics, kinetics, weightlifting, powerlifting*

RAZLIKE V NAVORU V KOLENU MED POČEPOM Z VISOKO IN NIZKO POSTAVITVIJO DROGA ZA GLAVO: PILOTNA ŠTUDIJA

IZVLEČEK

Namen: *Počep je ena najpogosteje uporabljenih vaj v sklopu športne vadbe, treninga in tekmovanj. Poznamo več različic počepa: počep z drogom, naloženim i) na sprednjem delu ramen (FS), ii) za glavo na zgornjih vlaknih kapucaste mišice (HBS) in iii) za glavo čez grebena lopatic (LBS). Ker je biomehanika tehnike LBS manj raziskana, je bil namen te pilotne študije analizirati razlike v neto mišičnem navoru v kolenu med tehnikama HBS in LBS.* ***Metode:*** *En zdrav merjenec moškega spola (180,0 cm; 76,0 kg; 26 let) je z dodatnim bremenom (40,4 kg) v enakomernem ritmu opravil 10 počepov (5 HBS in 5 LBS) do kota 90° v kolenu. Kinematični in kinetični podatki so bili zajeti z visokofrekvenčno kamero in s pritiskovno ploščo. S pomočjo inverzne dinamike so bili nato v dvodimenzionalnem prostoru izračunani največji (M_{max}) in povprečni (M_{avg}) neto mišični navori v kolenu.* ***Rezultati:*** *Rezultati so pokazali značilno večje M_{avg} pri tehniki HBS v primerjavi s tehniko LBS tako med celotnim obsegom gibanja (M_{avgHBS} = 221.6 ± 5.1 Nm, M_{avgLBS} = 203.3 ± 10.2 Nm; p = 0.026) kot tudi med ekscentrično (M_{avgHBS} = 226.0 ± 5.9 Nm, M_{avgLBS} = 202.0 ± 14.0 Nm; p = 0,043) in koncentrično (M_{avgHBS} = 216.2 ± 3.6 Nm, M_{avgLBS} = 205.0 ± 7.9 Nm; p = 0,021) fazo počepa ločeno.* ***Zaključek****: Zaključimo lahko, da so nižji M_{avg} pri tehniki LBS posledica prenosa obremenitev na kolčni sklep, najverjetneje zaradi večjega nagiba trupa anteriorno, kar predstavlja neposreden odziv na nižjo in bolj posteriorno postavitev droga za glavo in s tem ohranjanja ustrezne pozicije težišča telesa na podporno površino. Potrditev teh ugotovitev*

na večjem vzorcu bi pomenila, da je tehnika LBS primernejša takrat, ko želimo razbremeniti kolenski sklep.

Ključne besede: *inverzna dinamika, sila, kinematika, kinetika, dvigovanje uteži, powerlifting*

INTRODUCTION

The squat is one of the most widely used resistance exercises in the field of strength and conditioning (Schoenfeld, 2010) as it activates the largest, most powerful muscles in the body and is often regarded as the greatest test of lower-body strength (Escamilla, 2001; McCaw & Melrose, 1999).

The most studied variations of the squat are: the front squat (FS) with the bar held in front of the chest at the clavicle, the high-bar back squat (HBS) with the bar slightly above the level of the acromion across the upper trapezius muscles and the low-bar back squat (LBS) with the barbell positioned slightly below the level of the acromion across the spinae scapulae (Donnelly, Berg, & Fiske, 2006). Different variations of the squat are also an integral component in some sports. For example, in competitive weightlifting the FS is an essential component in the performance of the clean, whereas the HBS is most frequently used by athletes during strength training in various sports and by persons concerned with fitness (Gullett, Tillman, Gutierrez, & Chow, 2009). Conversely, the LBS technique is typical of competitive powerlifting (Schoenfeld, 2010).

In comparison with back squats, the FS has been found to produce lower maximal joint compressive forces on the knee and lower back, with little differences in shear forces and without compromising overall muscle recruitment in the quadriceps and hamstrings (Diggin et al., 2011; Gullett et al., 2009). However, due to flexibility limitations front squats are not as commonly used as back squats in training protocols. It must also be noted that for individuals untrained in the FS, this exercise should be eased into in order to maximize the loading stress on the target muscles while decreasing unnecessary stress to the relevant (particularly knee) joints via developing and exercising with proper techniques (Gullett et al., 2009).

As opposed to the upright posture while performing the FS, back squats require a more forward lean of the trunk in order to maintain balance and thus increase the load on the hip and back extensors (Braidot, Brusa, Lestussi, & Parera, 2007; Diggin et al., 2011; Fry, Smith, & Schilling, 2003). Several studies compared the biomechanics of front and back squats, however, the majority of previous studies focused mostly on 2D or 3D kinematics and / or kinetics of the front- vs. (high-bar) back-squat technique with different foot positions and squat depths, with (Gullett et al., 2009; Stuart et al., 1996) or without (Braidot et al., 2007; Diggin et al., 2011; Escamilla, Fleisig, Lowry, Barrentine, & Andrews, 2001; Russell & Phillips, 1989) muscle activation analysis. Swinton, Lloyd, Keogh, Agouris and Stewart (2012) performed a biomechanical comparison of

the traditional HBS with a self-selected narrow stance and the powerlifting style squat, where they only took into account a wider stance and greater forward lean of the trunk during the powerlifting squat execution, but failed to consider the lower placement of the bar on the back.

Since no research has been performed comparing the load on the knee joint between the HBS and the LBS it is believed, but not yet demonstrated, that the LBS technique produces greater hip and back extensor torque and less knee extensor torque than HBS, which translates into reduced patellofemoral compression and anterior cruciate ligament (ACL) strain in the LBS (Watkins, 1999, in Schoenfeld, 2010). In order to evaluate one of these assumptions, the purpose of this pilot study was to analyze knee joint net muscle torque differences between the HBS and LBS technique, hypothesizing lower maximal / peak and average net muscle torques during the LBS. This knowledge has an important practical value for coaches and therapists when dealing with specific training goals or with acutely or chronically injured athletes and patients.

METHODS

Subjects

One healthy male subject (height 180.0 cm, weight 76.0 kg, BMI 23.5 $kg \cdot m^{-2}$, age 26 years old), a student with five years of resistance training experience voluntarily participated in this pilot study. The study was performed according to the Helsinki declaration, while a written consent was not obtained since the measurements were performed within the framework of the study program at the University of Primorska.

Procedures

Six spherical reflective markers were placed over the 5^{th} lumbar vertebra, spina iliaca anterior superior, greater trochanter, lateral knee, lateral malleolus and fifth metatarsal head on the subject's right leg. Two additional markers on the floor were used for space calibration. The subject was wearing dark, fitting clothes in order for the markers to be visible and stable (Figure 1).

After the marker placement, the subject performed a standardized 6-minute warm-up (stepping on 25-cm high bench, tempo 120 min^{-1}, changing the leading leg each minute) and three to five practice squats without weight plates on the barbell for each squat type to get familiar with the pace of execution and range of motion. Verbal, tactile and audio feedback was given to the subject before, during, and after each familiarization set of squats, as well as during the main measurements. To guarantee the same pace of each repetition of each squat technique, a metronome was used and set so that the eccentric as well as the concentric phase of the squat was performed in 2 seconds – to-

taling at 4 seconds. Each repetition was performed to the knee angle of approximately 90° in order to descend to the same depth. To ensure the same depth and the same knee angle at the lowest point of the squats, a box/case on the top of a chair was used (at a height of 57 cm). During the execution of the task the subject had to reach and touch it with his buttocks, thus ensuring a tactile feedback (Figure 1). The subject then performed a total of 10 squat repetitions with additional load (barbell with weight plates weighing 40.4 kg (53.2 % BM)), five of which were performed in the HBS and five in the LBS technique using a self-selected stance width in order to achieve the subject's most natural feet position. Each repetition was performed separately, starting with five sequential repetitions using the HBS technique, followed by five sequential repetitions using the LBS technique (without randomization). Before each repetition, the force plate was recalibrated. In order to prevent fatigue, one- to two-minute rest periods were provided between repetitions.

Figure 1: High-bar back squat (HBS; left picture) and low-bar back squat (LBS, right picture) technique and the measurement setup.

Measurements

The movement was captured at the frequency of 120 Hz in a sagittal plane using a high-speed camcorder (FUJI FINEPIX HS10, Fujifilm Corporation, Tokyo, Japan). Two reflectors (LOWELPRO-LIGHT, Lowel-Light Manufacturing, Inc., Hauppauge, NY, USA) with the power of 250 W were placed next to the video camera. A force plate (AMTI HE600600-2k, Advanced Mechanical Technology, Inc., Watertown, MA, USA) was used to collect 3D ground-reaction forces with the sampling frequency set at 1200 Hz. The video camera and the force plate were synchronized before the subject executed each repetition.

Each reflective marker was automatically recognized, digitized and scaled using AviMes AD 2.4 (ISC Matej Supej s.p., Kranjska Gora, Slovenia) software (Holmberg, Lund Ohlsson, Supej, & Holmberg, 2013; Rasmussen et al., 2012). 2D data (x, y coordinates) were then smoothed using a 2-pass second-order critically damped low-pass Butterworth filter with the cut-off frequency of 6 Hz. The position and magnitude of the lower-extremity segmental masses, their velocities, accelerations and moments of inertia for each movement repetition were estimated using mathematical models and the subject's anthropometric data according to Winter (2009). Using Matlab R2013a software (The Mathworks, Inc., Natick, MA, USA) the ground-reaction force data were first synchronized with video data and reduced to 120 Hz, and then the net joint reaction forces and joints' net muscle torques were calculated for the lower extremity using an inverse dynamic analysis that combined the anthropometric, kinematic, and ground-reaction force data (Winter, 2009). Due to the differences in the duration among the squat repetitions (ranging from 3.59 – 3.92 s for HBS and from 3.69 – 4.17 s for LBS), each repetition was normalized in the time domain to 100 %. For each repetition of each squat technique minimum knee angles (α_{minHBS}, α_{minLBS}), maximal/peak (M_{maxHBS}, M_{maxLBS}) and average (M_{avgHBS}, M_{avgLBS}) knee joint net muscle torques were calculated as dependent variables. This was done for the entire range of motion for each squat (descending and ascending phase together), as well as for the eccentric (descending) and concentric (ascending) phase separately. The calculations were performed in the range of motion from 160° to the lowest angle in the knee joint and back to 160°. Due to an error in the ground-reaction force data capture during the first HBS measurement, the first repetition of each squat technique was excluded from the analysis.

Statistical Analysis

Statistical analysis was performed with IBM SPSS Statistics 20 package (IBM Corporation, Armonk, NY, USA). Homogeneity of variances using the Levene's test and normality of data distribution using the Shapiro-Wilk's test were performed first. To test the differences between maximal and average net muscle torques between the HBS and the LBS technique, a Paired-Samples T-test was used. Statistical significance for all analyses was set at p-level < 0.05 (2-tailed).

RESULTS

All parameters were normally distributed ($p > 0.05$) and had homogeneous variances ($p > 0.05$). The average knee joint net muscle torques and angles during the whole movement for four repetitions with each squat technique (HBS and LBS) are presented in Figure 2. The results of the Paired-samples T-test showed no significant differences between minimum knee angle ($\alpha_{minHBS} = 98.1 \pm 0.3°$, $\alpha_{minLBS} = 96.7 \pm 1.1°$; $p = 0.064$; $\alpha = 180°$ means maximally extended knee) and a significantly greater average net muscle torque at the knee joint during the squats using the HBS technique compared to the LBS, both during the entire range of the squat ($M_{avgHBS} = 221.6 \pm 5.1$ Nm, $M_{avgLBS} = 203.3 \pm 10.2$ Nm; $p = 0.026$) as well as during the eccentric ($M_{avgHBS} = 226.0 \pm 5.9$ Nm, $M_{avgLBS} = 202.0 \pm 14.0$ Nm; $p = 0.020$) and concentric ($M_{HBSavg} = 216.2 \pm 3.6$ Nm, $M_{LBSavg} = 205.0 \pm 7.9$ Nm; $p = 0.041$) phase respectively (Figure 3). However, there were no differences in maximal knee joint net muscle torque values during the eccentric and concentric phase respectively, not even if the entire range of motion was considered ($p > 0.05$).

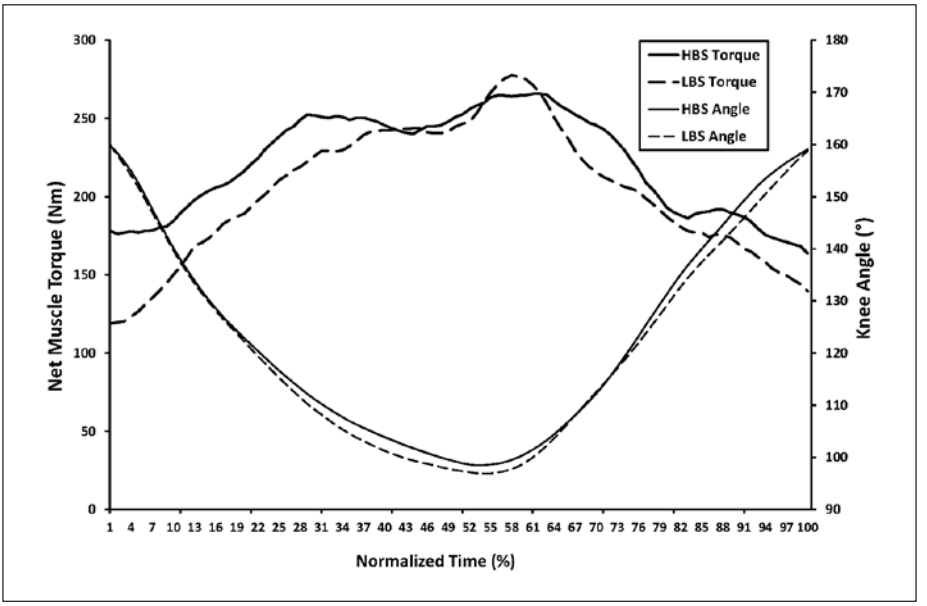

Figure 2: Knee joint net muscle torque and angle (average of 4 repetitions) during the high-bar back squat (HBS) and low-bar back squat (LBS).

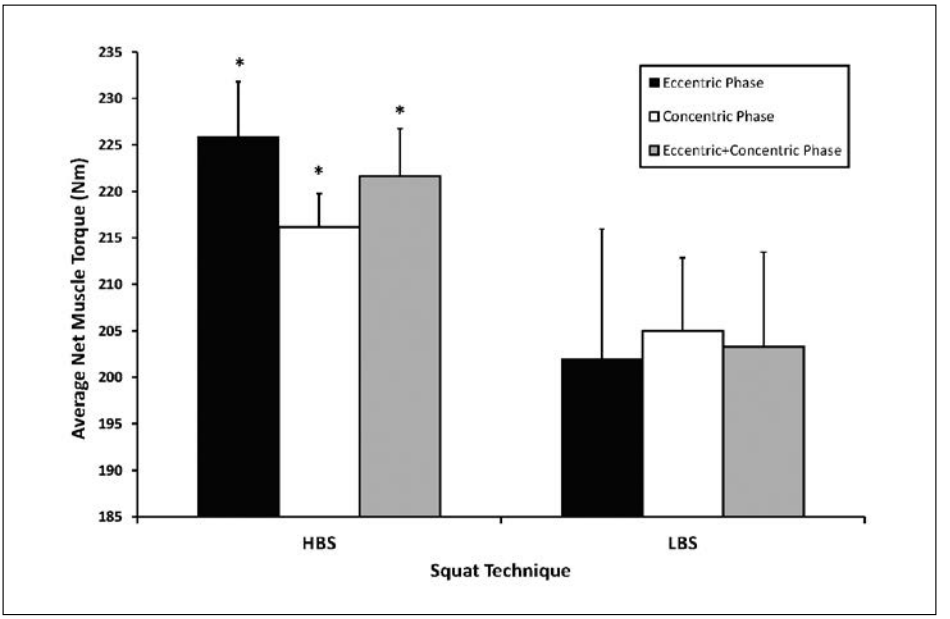

Figure 3: Average knee joint net muscle torques (M_{avg}) during the eccentric (black bars) and concentric (white bars) phase separately and during both eccentric and concentric phase together (grey bars). The asterisks (*) denote significant ($p < 0.05$) differences between the high-bar back squat (HBS) and low-bar back squat (LBS) technique. Averages and SDs of four repetitions of one subject are presented.

DISCUSSION AND CONCLUSIONS

The purpose of this pilot study was to analyze knee joint net muscle torque differences during the execution of two different squat techniques, the HBS and the LBS. The main finding was a significantly greater average net muscle torque at the knee joint while performing the HBS compared to LBS during the whole range of the squat as well as during the concentric and eccentric phase separately. However, there were no differences in maximal / peak net muscle torques.

Similarly to this study, Swinton et al. (2012) compared the HBS with a powerlifting style squat. However, they compared the HBS technique with a self-selected narrow stance to a powerlifting style squat, executed with a wider foot stance and a deliberate greater anterior inclination of the trunk. Moreover, Swinton and his colleagues (2012) failed to consider the lower position of the bar on the back while performing the powerlifting technique. Thus, they kept the high bar position constant during both squat variations and reported significantly greater peak torques at the hip and ankle joints

during the HBS compared to the powerlifting style squat, while there were lower or no different peak torques at the lumbar spine as well as at the knee joint. This is in contrast to the findings of the present study, where greater knee joint net muscle torque was observed during the HBS, which is most likely due to differences in the study design, its protocols and observed techniques. Additionally, the subject maintained a constant squat depth as well as stance width during both techniques while only the bar position on the back was manipulated.

Based on the results of the present study it can be concluded that the lower net muscle torques at the knee joint could be due to load transfer to the hip joint and lumbar spine when the LBS technique was adopted. This is most likely due to greater anterior tilt of the torso, which was not measured but is evident from Figure 1. This is most probably a direct response to a lower and more posterior bar placement on the back to finally maintain the centre of mass unchanged and potentially translating into reduced patellofemoral compression and ACL strain during the LBS, as also proposed by Schoenfeld (2010). Thus, we can assume that the knee joint forces over the entire range of motion during the LBS are lower compared to the HBS.

On the other hand, in this study other joints' net muscle torques were not considered, which in addition to single subject measurements is one of the main limitations. Moreover, future research should examine 3D kinematic and kinetic as well as muscle activation differences at the ankle, knee, hip and lumbar spine with different foot position.

In conclusion, it has to be emphasized that the performed study represents a small, pilot scientific work, whose results are valid and entirely applicable solely for the subject taken into consideration and at present they cannot be generalized. However, a confirmation of these findings on a larger sample would imply that the LBS could be more appropriate when knee joint relief is desired. This could prove to be useful for coaches and therapists when dealing with specific training goals (i.e. precise localization of the training effects) or with acutely or chronically injured athletes and patients, such as patellofemoral problems, ACL or collateral ligament injuries.

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REWIEVS / POROČILA, 153–156

INTERNATIONAL SCIENTIFIC AND EXPERT CONFERENCE "CHILD IN MOTION 2014"

This year, the eighth International Scientific and Expert Conference "Child in Motion / Movement" was organized by the University of Primorska, Science and Research Centre, Institute for Kinesiology Research IKARUS and the Faculty of Education in collaboration with the University of Ljubljana, Faculty of Education and the University of Maribor, Faculty of Education. The conference was held from 2nd to 4th October 2014 at the Bernardin Congress Centre.

"Kinesiology − the science of movement has an increasingly important role in the modern society as well as a responsibility of promoting an active lifestyle and ensuring a healthy and balanced development of each individual. We can build effective and lasting change only through young people. Children are our future, so it is necessary to start early enough with studying the movement competencies and the related knowledge," said Professor Rado Pišot, Ph.D., the Chair of the Scientific Council Conference.

The conference was carried out under the slogan "Kinesiology − the path of health," which highlighted the interdisciplinary approach, typical of this scientific discipline. The aim of the conference was to bring together scientific knowledge and examples of good practice in the field of kinesiology and other scientific disciplines and professional fields, which together contribute significantly to the understanding of the interconnectedness of physical activity and the health of our children and youth. The conference was attended by kinesiologists, teachers and educators as well as medical doctors, researchers and practitioners in the subject area who came from nine different countries. With the latest findings and examples of good practice they contributed to the promotion of quality and health-friendly motor / physical development of children. The key thematic areas were biomechanical and physiological aspects of motor / physical development of children; motor competencies and skills in the development of children; psychological, social and pedagogical aspects of motor / physical development of children; medical aspects of motor / physical development of children; nutrition and children's health, and sports for children and adolescents.

Preliminary plenary contributions, collected in the conference proceedings, were presented by internationally renowned experts who in their respective fields of research represent the world's summit: Shawnda Morrison "Thermoregulation in Children: Exercise, Heat Stress and Hydration"; Andrea B. Maier "The Importance of Physical Activity and Childhood as a Lever of Healthy Aging"; Karin Hind "Current Perspectives on Exercise for Bone Health and Paediatric Population"; Sergej M. Ostojič, Marko Stojanovič, Dejan Madič "Aerobic Fitness vs. Adiposity in Children: Is It Better to be Fat and Fit than Thin and Sedentary?"; Aleš Pražnikar, Anton Zupan "Gait Dysfunction in Children with Neuromuscular Disorders". In continuation of the conference the contributions were presented by the following introductory speakers: Mladen Gasparini "Injuries in Children − a Growing Problem?"; Inger Karlefors "Where did the How Go − about Teaching Methods in Swedish PEH"; Rado Pišot "Development of Motor

Competences inChildhood − the Foundation for an Active and Healthy Adulthood"; Dragan Radovanovič "Resistance Exercise for Children and Adolescents: Myths and Facts?"; Bostjan Šimunič, Katja Koren, Rado Pišot "Developmental Adaptation of Skeletal Muscle's Composition" and Dorjan Zerbo Šporin "The Processes of Changing in Children's Body Composition − a Review". These were followed by numerous scientific presentations by the participants in the scientific work and, in particular, the presentations of good practice examples in the professional part of the conference, all of them being concluded by lively discussions. The participants took the opportunity of the accompanying social program of the conference for pleasant social gathering, making acquaintances and networking. The next conference will be in 2016.

Iztok Retar

REWIEVS / POROČILA, 153–156

MEDNARODNA ZNANSTVENA IN STROKOVNA KONFERENCA "OTROK V GIBANJU 2014"

Letošnjo že osmo mednarodno znanstveno in strokovno konferenco **"**Otrok v gibanju**"** sta organizirala Univerza na Primorskem, Znanstveno-raziskovalno središče, Inštitut za kineziološke raziskave IKARUS in Pedagoška fakulteta v sodelovanju z Univerzo v Ljubljani, Pedagoško fakulteto ter Univerzo v Mariboru, Pedagoško fakulteto. Konferenca je potekala od 2. do 4. oktobra 2014 v Kongresnem centru Bernardin v Portorožu.

"Kineziologija – znanost o gibanju ima v sodobni družbi vse pomembnejšo vlogo in odgovornost pri spodbujanju aktivnega življenjskega sloga ter zagotavljanju zdravega in uravnoteženega razvoja posameznika. Le na najmlajših lahko gradimo učinkovite in trajne spremembe. Otroci so naša prihodnost, zato je s preučevanjem gibalnih kompetenc in vedenj nujno pričeti dovolj zgodaj", je poudaril prof. dr. Rado Pišot, predsednik Znanstvenega sveta konference.

Konferenca je potekala pod geslom Kineziologija – pot zdravja, s katerim so izpostavili interdisciplinaren pristop, značilen za to znanstveno vedo. Cilj konference je bil združiti znanstvena spoznanja in primere dobre prakse s področja kineziologije ter drugih znanstvenih disciplin in strokovnih področij, ki skupaj pomembno prispevajo k razumevanju prepletenosti gibalne aktivnosti z zdravjem naših otrok in mladostnikov. Konference so se udeležili iz devetih držav tako kineziologi, pedagogi in vzgojitelji kot zdravniki in raziskovalci ter praktiki s predmetnega področja. Z najnovejšimi spoznanji in s primeri dobrih praks so prispevali k razumevanju in uveljavljanju kakovostnega in zdravju prijaznega gibalnega razvoja otrok. Ključna tematska področja so bila biomehanski in fiziološki vidiki gibalnega razvoja otroka, gibalne kompetence v razvoju otroka, psihološki, socialni in pedagoški vidiki gibalnega razvoja otroka, medicinski vidiki gibalnega razvoja otroka, prehrana in zdravje otrok ter šport otrok in mladostnikov.

Uvodne plenarne prispevke, zbrane v konferenčnem zborniku, so predstavili mednarodno uveljavljeni strokovnjaki, ki na svojem področju raziskovanja sodijo v sam svetovni vrh na tematskih področjih: Shwanda Morrison "Thermoregulation in children: exsercise, heat stress and hidration"; Andrea B. Maier "The importance of Physical activity in childhood as a lever of healthy ageing"; Karin Hind "Curent perspectives on exercise for bone health in pediatric population"; Sergej M. Ostojić, Marko Stojanović in Dejan Madić "Aerobic fitness vs. adiposity in children: is it better to be fat and fit than thin and sedentary?" ter Aleš Pražnikar in Anton Zupan "Gait dysfunction in children with neuromuscular disorders". V nadaljevanju so prispevke predstavili uvodni predavatelji: Mladen Gasparini "Injuries in children – a growing problem?"; Inger Karlefors "Where did the how go – about teaching methods in Swedish peh"; Rado Pišot "Development of motor competences in childhood – the foundation for an active and healthy adulthood"; Dragan Radovanović "Resistance exercise for children and adolescents: myths and facts?"; Boštjan Šimunič, Katja Koren in Rado Pišot "Developmental adaptation of skeletal muscle's composition" ter Dorjana Zerbo Šporin "The processes of changing in children's body composition – a review". Sledile so

številne znanstvene predstavitve sodelujočih v znanstvenem delu ter predstavitve zlasti primerov dobre prakse v strokovnem delu konference, ki so jih sklenili z razgibano razpravo. Udeleženci so spremljajoči družabni program konference izkoristili še za prijetno druženje, navezovanje stikov in mreženje. Naslednja konferenca bo v letu 2016.

Iztok Retar

GUIDELINES FOR AUTHORS, 157–161

GUIDELINES FOR AUTHORS

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

2. **General policy of Annales Kinesiologiae**
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d) The title page should include the title of the article (no more than 85 characters, including spaces), full name of the author(s) and affiliations (institution name and address) of each author; linked to each author using superscript numbers, as well as the corresponding author's full name, telephone, and e-mail address.

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

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

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

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

i) Captions are required for all **Figures** and shall appear on a separate manuscript page, under the table captions. Each figure should be saved as a separate file without captions and named as Figure 1, etc. Files should be submitted in *.tif or *.jpg format. The minimum figure dimensions should be 17 x2 0 cm and a resolution of at least 300 dpi. Combinations of photo and line art should be saved at 600–900 dpi. Text (symbols, letters, and numbers) should be between 8 and 12 points, with consistent spacing and alignment. Font type may be Serif (Times Roman) or Sans Serif (Arial). Any extra white or black space surrounding the image should be cropped. Ensure that participant-identifying information (i.e., faces, names, or any other identifying features) should be omitted. All figures should be numbered consecutively Figure 1, etc. The preferred location of the figure in the main text should be indicated preferably in a style as follows: *** Table 1 somewhere here ***.

j) References

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

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

Examples of reference citation in the text

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

Two authors: This result was later contradicted (Greene & Roberts, 2005) or Greene and Roberts (2005) pointed out ...

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

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

Journal articles
Šarabon, N., Kern, H., Loefler, S., & Rošker. J. (2010). Selection of body sway parameters according to their sensitivity and repeatability. Basic and Applied Myology, 20(1), 5–12.
De Boer, M. D., Seynnes, O., Di Prampero, P., Pišot, R., Mekjavić, I., Biolo, G., & Narici, M. V. (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 measures physical activity in girls and boys before and after long summer vacations. In V. Štemberger, R. Pišot, & K. Rupret (Eds.) Proceedings of 5th International Symposium A Child in Motion "The physical education related to the qualitative education" (pp 496–501). Koper: University of

Primorska, Faculty of Education Koper, Science and research centre of Koper; Ljubljana: University of Ljubljana, Faculty of Education.

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

4. Manuscript submission

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

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

Reviewing process communication will proceed via e-mail.

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


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