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CONTENTS

AEROBIC TRAINING DOES NOT IMPROVE COMPETITIVE PERFORMANCE IN YOUNG ELITE BASKETBALL PLAYERS

Carlos Claramunt[1], Ivar Guzman[1], Joan Solé[1], Natàlia Balagué[1], Robert Hristovski[2]
University of Barcelona[1], Barcelona, Spain
University of Ss. Cyril and Methodius[2], Skopje, Macedonia

ABSTRACT

Research background and hypothesis. While for some authors team sport players should have a high VO_2max, we hypothesize that there exist a non-linear relationship between VO_2max and basketball performance.

Research aims. Research aims were to study the correlation between basketball performance and VO_2max in young elite basketball players and the effects of VO_2max training on performance.

Research methods. In the first study, 67 high-level young basketball players performed a shuttle-run test (SRT) to measure their VO_2max. Competition performance assessed through statistics ratings of 5 matches was determined for all players. The correlation between VO_2max and performance was calculated. In the second study, the VO_2max and the competition performance of 34 high-level young male players was assessed as in the first study. The sample was divided into control and experimental groups, which trained their VO_2max. At the end of the training period all participants repeated the SRT. The results of 4 games played before the first test and 4 games played after the second test (against the same opponents) were compared in both groups.

R**esearch results.** In the first study we found a correlation of VO_2max with steals in both groups. In the second study, the experimental group increased their VO_2max and steals per game, but they decreased free throw per game and free throw percentage.

Discussion and conclusions. No correlation was found between VO_2max and competitive performance in this study, and increased VO_2max had no effect on most of the studied variables. The data therefore suggest a non-linear relationship between VO_2max and basketball performance.

Keywords: aerobic capacity, basketball performance, non-linear relationship.

INTRODUCTION

It is difficult to quantify players' performance in team sports due to the extreme complexity and variety of game actions. Traditionally, performance has been considered to be the sum of several aspects: physical level (endurance, strength, velocity, etc.), adequate technique, correct tactical decisions and self-control in pressure situations, etc. In recent years many tests have been developed to assess each of these components separately, the main objective being to monitor and train these capacities on an individual basis.

In order to quantify the performance of players in competitive settings the game is broken down into isolated actions that are later quantified. Game statistics, which are especially popular in baseball and basketball, determine the player's overall

performance using several formulas (Berri, 2000). However, there are at least two key questions that require further investigation: is competitive performance equivalent to the sum of a limited set of isolated actions or to the sum of different qualities assessed through specific tests? Is there a linear relation between performance components and the competitive performance itself, i.e. would training and improving a single component (such as VO_2max) produce a concomitant improvement in the overall competitive performance?

One of the main indicators of the level of aerobic capacity development is VO_2max. Its importance in competitive performance is well-known and rests on the relationship between aerobic capacity and both repeated sprint ability (RSA) and phosphocreatine levels (Bishop et al., 2004). In addition, a decrease in intracellular pH due to low aerobic capacity may also contribute to the decline in power output during RSA via inhibition of glycolysis (Westerblad et al., 2002). Thus, the main aim of a typical physical training programme in team sports is to increase aerobic capacity together with strength and speed, which would be expected to improve the player's overall performance. The relationship between increased VO_2max and the total distance ran and the distance covered at high-running speed has already been studied in soccer (Impellizzeri et al., 2005). In competitive basketball, especially in young players, an increase in VO_2max levels seems crucial because of the fast movements performed throughout the game and the fact that aerobic metabolism is the predominant energy source (Abdelkrim et al., 2007). Consequently, we hypothesise that an increase in VO_2max will have an effect on match performance.

Although it is commonly assumed that there is a linear relationship between physical condition components and performance, some recent experiments have shown non-linear relationships between these components: for example, between strength training and aerobic capacity (Paavolainen et al., 1999) and speed and strength (Wisloff et al., 1998), among others. It is therefore unclear whether an increase in VO_2max will produce a linear improvement in the performance of a basketball player, as there may be interactions with other components. This is a common effect in complex adaptive systems the behaviour of which being the result of an immense number of coordinated spatio-temporal processes, is highly non-linear (Hristovski et al., in press).

In other words, their macroscopic behaviour (e. g. their performance) is a collective effect of sets of highly interdependent components within the system, i.e. a result of their synergy in space and time.

The aim of this study was therefore twofold:

A) To study the correlation between individual basketball performance (assessed on the basis of basketball statistics) and aerobic capacity in young high-level basketball players.

B) To study the effects of aerobic capacity training on competitive performance in the same population.

RESEARCH METHODS

FIRST STUDY

Participants. Sixty-seven male elite basketball players (mean age 12.89 ± 0.49 years) belonging to six different teams participated in the study. They were all informed about the study characteristics and signed a written consent form. The sample was divided into two groups: Group A comprised 33 players aged 13 years, while Group B included 34 players aged 12 years. They all engaged in a total of 4.5 hours of basketball training per week, as well as 3 hours per week of physical training.

Procedure. In both groups VO_2max was estimated through a 20 m SRT performed on two occasions, five weeks apart. The formula used was: VO_2max (ml / kg · min) = $31.025 + 3.238 ·$ speed in km / h $– 3.248 ·$ age $+ 0.1536 ·$ speed in km / h · age (Léger et al., 1988). All participants wore a portable heart-rate monitor to test their maximum heart rate, thereby ensuring maximum effort. Before each test, height and weight was measured to ensure that any possible modification in aerobic capacity would not be due to morphological changes.

Between the first and the second test the participants played five matches, all of which were statistically analysed. A total of 30 matches were studied and the evaluated variables were: points, rebounds (offensive, defensive and total), assists, blocks, blocks received, steals, turnovers, 1, 2 and 3 field goals (missed, made and attempted), personal fouls, and personal fouls received.

Data analysis. In order to compare different teams the data were standardised to 100 team ball possessions (Góme, Lorenzo, 2008) using the following formula: Team ball possessions = field goal attempts $+ 0.5 ·$ free throw attempts $–$ offensive rebounds $+$ turnovers.

These data were then used to calculate the player efficiency rating by applying the ACB League formula (Martínez J. A., Martínez I., 2010): ACB League Rating = points + assists + blocks + steals + received fouls + field goals made + 3 points field goal made – received blocks – turnovers – missed free throws – field goal attempted – personal fouls.

Descriptive statistics of height, weight, VO_2max HRmax and performance formulas were then calculated. To ensure a normal sample distribution the Shapiro-Wilks test was applied. The significance of any differences between the first and the second VO_2max tests was assessed by means of the Student's t test. Finally, we calculated the r value for the correlation between match performance and aerobic capacity. Statistical significance was set at $p < 0.05$.

RESEARCH RESULTS

Tables 1 and 2 show the descriptive statistics of height, weight, VO_2max, HRmax and the performance indicators for both groups. There were no significant differences between the first and second SRT, neither in terms of VO_2max (Group A: $p = 0.295$; Group B: $p = 0.332$) nor HRmax (Group A: $p = 0.658$; Group B: $p = 0.498$). These results indicate that aerobic capacity did not change significantly in the five-week period between the two tests.

Table 2 shows the correlations between VO_2max and basketball performance in terms of the statistical variables. Only "steals" showed a positive correlation in both groups (Group A: $r = 0.434$; Group B: $r = 0.661$), while the other correlations were very low.

SECOND STUDY

Participants. Three teams comprising 34 elite basketball players (mean age 12.49 ± 0.49 years) participated in this study. All subjects were informed about the purposes of the study and gave their written consent. The sample was divided into two groups: Group E (aerobic training) included 14 players, while Group C (control group) comprising the remaining 20 players.

Procedure. VO_2max was determined by the SRT, similarly to the procedure in the first study. Each team was divided into two homogenous groups according to their initial aerobic capacity. Both groups engaged in 4.5 hours of basketball training per week, plus 3 hours of physical training. In addition, Group E performed aerobic capacity training three times per week over a six-week period. Overall, Group E trained each week for approximately 1 hour 30 minutes more than Group C. The aerobic capacity training consisted of series

Table 1. **Descriptive data for both groups**

Variables / Groups		Height, cm	Weight, kg	HRmax, beats / min	VO_2max, ml / kg·min
Group A (n = 33)	Mean (± SD)	174.48 (± 10.23)	61.68 (± 11.51)	202.7 (± 6.49)	51.44 (± 4.7)
Group B (n = 34)	Mean (± SD)	167.47 (± 10.9)	56.77 (± 11.2)	203 (± 8.52)	49.5 (± 5.33)

Table 2. **Correlations between VO_2max and basketball performance assessed according to competitive statistics**

Group	Minutes played	Points per game	Personal fouls per game	Personal fouls received per game	Rebounds per game	Defensive rebounds per game	Offensive rebounds per game	Steals per game	Blocks per game	Assists per game	Turnovers per game	Free throws made per game	Free throw attempts per game	Free throw percentage	2-points made per game	2-point attempts per game	2-point percentage	3-points made per game	3-point attempts per game	3-point percentage	ACB League formula
A	0.146	0.079	0.165	−0.116	−0.249	−0.218	−0.430*	0.434*	−0.191	0.29	−0.079	−0.102	−0.344	0.258	0.365	0.349	0.146	0.235	0.134	0.216	0.069
B	0.132	0.263	−0.113	0.173	0.078	0.095	0.04	0.661**	0.117	−0.01	0.18	−0.113	−0.001	0.046	−0.038	−0.151	0.14	0.262	0.094	0.356	0.389*

Note. * – $p < 0.05$ ** – $p < 0.01$

of 7–10 min at 65–75% of VO_2max, 4–5 min at 70–85% of VO_2max and 2–4 min at 90–120% of VO_2max. The rest period between series lasted between 1 min and 5 min. A second SRT was performed at the end of the training period.

As in the previous study, basketball statistics were determined according to team ball possessions. Each player's competitive performance was established on the basis of statistics derived from four matches played before the first test and four matches played after the second test. These four pre and post matches were played against the same teams.

Finally, descriptive statistics of height, weight, VO_2max, HRmax and the performance indicators were calculated. To ensure a normal sample distribution the Shapiro-Wilk test was applied. The significance of any differences between these variables at the first and second testing points was assessed by means of the Student's *t* test. Statistical significance was set at $p < 0.05$.

RESEARCH RESULTS

Table 3 shows the descriptive statistics of height, weight, VO_2max, HRmax and the performance indicators for both groups. The pre- and post-training VO_2max values for the experimental group were 50.9 ml / kg · min and 53.98 ml / kg · min, respectively, this difference being statistically significant ($t = -6.31$; $p < 0.01$). There was also an increase in the number of steals per game ($t = -2.27$; $p < 0.05$), coupled with a decrease in both the number of free throws made ($t = 2.40$; $p < 0.05$) and the percentage of free throws ($t = 2.96$; $p < 0.05$). In the control group none of the variables changed significantly.

DISCUSSION

The first study found no correlation between aerobic capacity and the ACB League player efficiency rating in the group of 13-year-olds,

Table 3. **Values of the variables studied in the experimental and control groups before and after the aerobic capacity training period**

Group / Variables	Experimental		Control	
	Before	**After**	**Before**	**After**
Height	171.21 (± 11.07)	172.88 (± 11.01)	170.21 (±12.81)	171.95 (± 13.15)
Weight	60.35 (± 12.69)	61.63 (± 12.71)	60.14 (±14.22)	61.77 (± 14.17)
VO_2max (ml / kg · min)	51.89 (± 5.29)	55.18 (± 4.92)**	52.66 (± 4.65)	53.22 (± 3.57)
HR_{max}	200.61 (± 8.22)	201.15 (± 8.32)	207.18 (± 7.60)	207.31(± 7.21)
Minutes played	19.04 (± 2.35)	19.83 (± 2.35)	19.40 (± 2.37)	20.98 (± 1.70)
Points per game and player	13.17 (± 5.52)	12.84 (± 5.80)	11.83 (± 5.74)	12.16 (± 6.98)
Personal fouls per game and player	1.82 (± 0.61)	1.64 (± 0.65)	1.91 (± 0.70)	1.59 (± 1.01)
Personal fouls received per game and player	1.60 (± 0.75)	1.54 (± 0.66)	1.79 (± 0.79)	1.94 (± 1.13)
Rebounds per game and player	4.48 (± 3.40)	4.61 (± 3.24)	3.17 (± 1.69)	3.04 (± 1.63)
Defensive rebounds per game and player	2.87 (± 1.01)	2.74 (± 1.28)	2.35 (± 1.12)	1.83 (± 1.02)
Offensive rebounds per game and player	1.60 (± 2.19)	1.87 (± 2.17)	0.83 (± 0.75)	1.21 (± 0.93)
Steals per game and player	2.79 (± 2.40)	3.87 (± 2.22)*	3.01 (± 1.68)	3.5 (± 1.55)
Blocks per game and player	0.08 (± 0.12)	0.38 (± 0.35)	0.23 (± 0.26)	0.09 (± 0.22)
Assists per game and player	2.19 (± 1.31)	1.88 (± 1.45)	1.73 (± 1.19)	2.16 (± 1.65)
Turnovers per game and player	1.47 (± 0.79)	1.89 (± 0.89)	1.36 (± 0.58)	1.73 (± 0.54)
Free throws made per game and player	1.38 (±0.06)	0.95 (± 0.06)*	1.27 (± 0.67)	1.23 (± 0.89)
Free throw attempts per game and player	2.23 (± 0.89)	2.15 (± 1.29)	2.13 (± 1.07)	2.14 (± 1.34)
Free throw percentage	61.93 (± 21.48)	44.02 (± 17.4)*	59.43 (± 34.59)	57.19 (± 22.15)
2-points made per game and player	5.48 (± 2.5)	5.74 (± 9.2)	4.77 (± 2.60)	4.18 (± 3.09)
2-point attempts per game and player	8.2 (± 3.15)	8.43 (± 12.49)	7.42 (± 3.47)	6.25 (± 4.13)
2-point percentage and player	66.87 (± 15.9)	68.07 (± 11.22)	64.25 (± 12.35)	66.89 (± 14.40)
3-points made per game and player	1 (± 1.25)	0.9 (± 1.26)	1.16 (± 1.47)	1 (± 1.54)
3-point attempts per game and player	2.4 (± 2.76)	2.5 (± 3.21)	2.66 (± 3.11)	2.88 (± 3.23)
3-point percentage	41.67 (± 33.48)	36 (± 34.54)	43.61 (± 34.52)	34.72 (± 38.46)
ACB League formula	17.10 (± 7.29)	17.33 (± 7.30)	14.56 (± 8.17)	14.93 (± 9.73)

Note. * – $p < 0.05$, ** – $p < 0.01$.
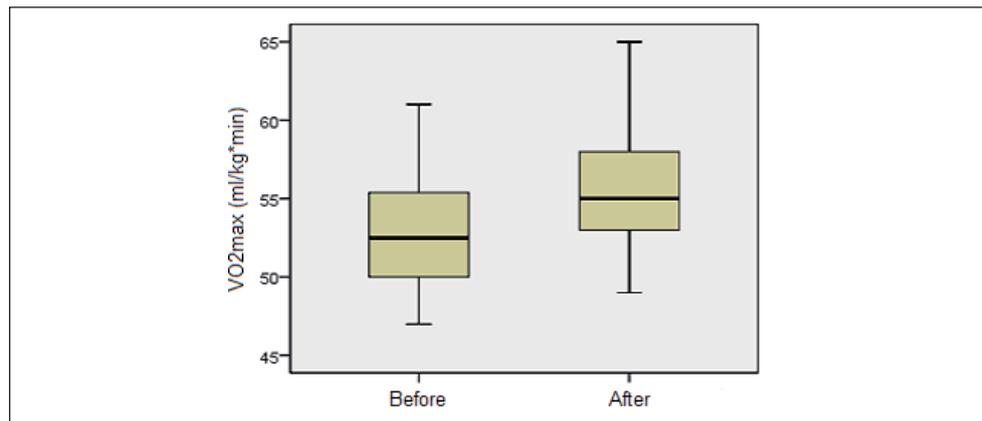
Figure 1. **VO₂max before and after the aerobic training period in the experimental group**
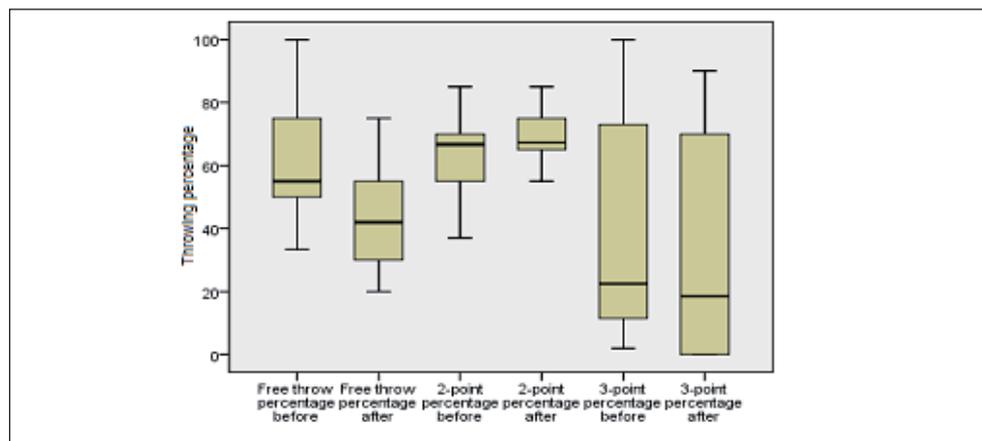
Figure 1. **VO₂max before and after the aerobic training period in the experimental group**
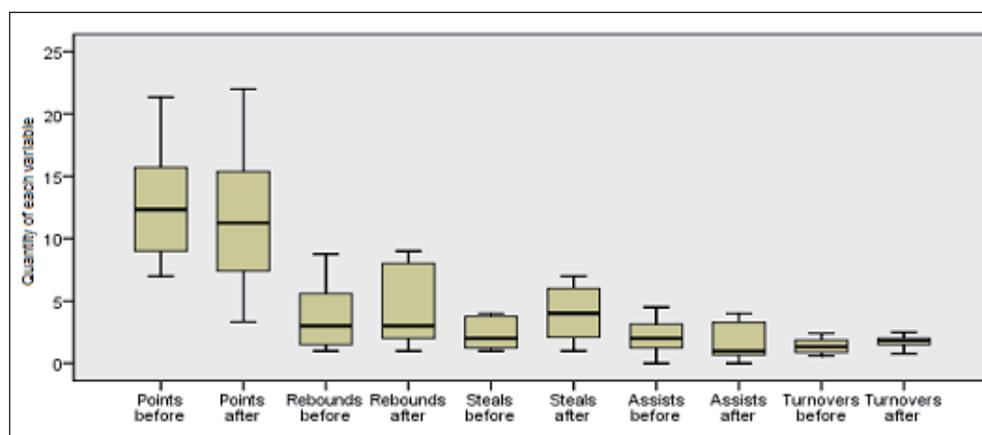
Figure 3. **Most notable basketball statistics before and after the aerobic training period in the experimental group**

while the correlation was very low among the 12-year-olds. There was a moderate correlation between aerobic capacity and the number of steals in both groups, and a low negative correlation with offensive rebounds in the group of 13-year-olds. In the second study the increased aerobic capacity of the experimental group had no effect on most of the variables studied. Specifically, it only had a positive effect on the "steals" variable, while there was a negative effect on the number of free throws made and the free throw percentage.

The basketball variables studied were those usually analysed in national and international championships. The ACB player efficiency rating is one of the most widely used in European basketball, despite there being other formulas (Manley, 1989), all of which are highly correlated with ACB ratings (for example, those of the NBA; $r = 0.98$).

The 20 m SRT is an indirect test that shows a high correlation ($r = 0.89$) with real aerobic capacity in children (Léger et al., 1988). The VO₂max values found here were higher than those reported in a population of a similar age (Mota et al., 2002), although to our knowledge there are no similar studies about the aerobic capacity of young male elite basketball players.

In the first study the only variable that correlated with VO₂max was the number of steals ($r = 0.434$ and $r = 0.661$ in groups A and B, respectively). This

is probably due to the pace at which basketball is played by 12–13-year-olds. The six participating teams utilised pressing defences with guard and forwards during all the matches. Guards tended to have a higher aerobic capacity than do forwards and centres. However, we did not classify the players according to their position due to their versatility at this age. Correlations between aerobic capacity and both the ACB efficiency formula (r = 0.389; p < 0.05) and the number of offensive rebounds (r = 0.430; p < 0.05) were very low, indicating the weak association between VO_2max and these variables. These results suggest that in a high-level basketball group, aerobic capacity is not related to competitive performance.

It should be noted that some studies have found a correlation between VO_2max and soccer level. U. Wisloff et al. (1998) found a significant difference in VO_2max between the top and lower placed teams in the elite Norwegian division. Other studies in soccer have found a relationship between VO_2max and the number of sprints and high-intensity running (Krustrup et al., 2005), as well as between the total distance covered during a match and the aerobic capacity (Bangsbo, Lindquist, 1991). However, some authors have argued that the total distance covered during a soccer match seems to be a poor indicator of soccer performance (van Gool et al., 1988). Other factors such as the number of correct passes, correct tactical decisions, and adequate sport technique seem to have a greater effect than VO_2max on match performance.

In the second study the experimental group underwent aerobic capacity training according to the criteria established in the literature for this age group (Payne, Morrow, 1993). Three days per week over a six-week period is the minimum standard for any aerobic training programme. The increase obtained in aerobic capacity (from 51.89 to 55.18 ml / kg · min; p < 0.01) represents an increase of 6.3%, which is consistent with the results obtained in other studies that have reported similar responses to aerobic training in children (Payne, Morrow, 1993).

A recent study has reported that points, field goal percentage, assists and defensive rebounds are the most relevant statistical variables in basketball (Ibáñez et al., 2008). The present study found no change in any of these variables after the aerobic training (Table 3 and Figures 2 and 3), and it therefore seems that an increase in VO_2max is not associated with better competitive performance. We did observe an increase in a less important statistical variable, the number of steals per game (2.79 vs. 3.87; p < 0.05), although this is probably due to the guards' pressing defence. In the present study, aerobic training was also associated with a decrease in both the free throw percentage (61.93% vs. 44.02%; p < 0.05) and the number of free throws made per player (1.38 vs. 0.95; p < 0.05). The importance of the free throw percentage is minimal in unbalanced games, but it is very strong in the balanced ones (Gómez et al., 2008).

A possible explanation for our results is the detrimental effect that excess aerobic training can have on strength and speed (McCarthy et al., 1995). Unfortunately, we did not evaluate other physical capacities in order to check for possible interferences. Another point to note is that the relationship between aerobic capacity and exercise

Figure 4. **A schematic representation of possible types of experimental results**

Note. The relationship of dependence between a player's efficiency and a given independent variable is non-linear, shown by the thin continuous line. A piece-wise linear approximation: A – there is a strong, approximately linear dependence; B – a weak, approximately linear dependence; C – there is no dependence. While in A and B the change in a player's efficiency is proportional to the changes in the independent variable, in region C this proportionality breaks down. Circles simulate a data scatterplot.

recovery appears to have certain limitations. In a study of infantry soldiers performing the line drill, J. R. Hoffman (1997) found that the fatigue index was significantly higher in soldiers who had aerobic fitness levels that were one and two standard deviations below the population mean. However, as aerobic fitness improved, no further benefit in the fatigue index was observed. This is suggestive of a clear non-linear saturation effect (Fig. 4). In contrast to our results, some authors have found that greater aerobic capacity leads to an increase in the total distance covered during a soccer game, as well as the time played at high intensity (Impellizzeri et al., 2005). The main problem with these studies is that the number of matches analysed was very low, and these improvements could have been influenced by several factors, including the importance of the match, the skill level of the opposition, seasonal variation and the tactical approach used (Stone, Kilding, 2009). Other aspects related with the player's position may also affect the results.

In fact, frequent inconsistencies of research results accumulated over the years may mean that relationships among the variables defining athletic abilities are context dependent, and also that both the training process and population differences strongly constrain and shape the matrix of associations between the capacities studied. Hence, inter-variable relationships emerge under constraints, and the tacitly held assumption of invariant structural relationships, which should be discovered by cleverly performed experiments, may be a dead end. If this is so, then researchers need to turn their attention to the study of constraint effects.

CONCLUSIONS AND PERSPECTIVES

In summary, the present results do not corroborate a linear relationship between physical conditioning components and competitive performance, and throw into question the excessive aerobic training programmes administered to young elite basketball players. The context dependency of competitive performance and the non-linear interactions between physical capacities point to the need to study these phenomena under the framework of non-linear dynamic systems theory.

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AEROBINĖ TRENIRUOTĖ NEPAGERINA JAUNŲ DIDELIO MEISTRIŠKUMO KREPŠININKŲ VARŽYBINĖS VEIKLOS

Carlos Claramunt[1], Ivar Guzman[1], Joan Solé[1], Natàlia Balagué[1], Robert Hristovski[2]
Barselonos universitetas[1], Barselona, Ispanija,
Šv. Kirilo ir Metodijaus universitetas[2], Skopjė, Makedonija

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Kai kurie autoriai mano, kad komandinio sporto žaidėjai turėtų būti didelio aerobinio pajėgumo, kiti – kad per didelis ištvermės ugdymas gali pakenkti tokiems fizinės būklės komponentams kaip jėga ar greitis.

Tikslas: nustatyti jaunų krepšininkų žaidimo ir VO_2max rodiklių koreliaciją ir įvertinti, kaip aerobinio pajėgumo ugdymas veikia ją.

Metodai. Pirmo tyrimo metu didelio meistriškumo krepšininkai (12–13 m. amžiaus) atliko šaudyklinio bėgimo testą ir pamatuotas jų VO_2max. Tiriamieji buvo padalyti į A (33 trylikamečiai) ir B (34 dvylikamečiai) grupes. Įvertinta visų žaidėjų varžybinė veikla pagal penkių rungtynių statistinius reitingus. Apskaičiuota koreliacija tarp žaidėjų VO_2max ir krepšinio žaidimo rodiklių. Antru tyrimu nustatyti 34 didelio meistriškumo krepšininkų (trylikamečių) aerobinio pajėgumo ir varžybinės veiklos rodikliai taip, kaip ir per pirmą tyrimą. Tiriamuosius padalijome į kontrolinę ir eksperimentinę grupes. Pratybų pabaigoje visi tiriamieji pakartojo šaudyklinio bėgimo testą. Tada palyginome abiejų grupių ketverių rungtynių rezultatus prieš pirmą testą ir po antro (žaidžiant prieš tuos pačius varžovus).

Rezultatai. Pirmu tyrimu nustatyta VO_2max ir atkovotų kamuolių skaičiaus koreliaciją abiejose grupėse. Antro tyrimo metu eksperimentinės grupės žaidėjų VO_2max rodikliai buvo geresni ir per vienas rungtynes jie daugiau atkovojo kamuolių, tačiau metimų skaičius per vienas rungtynes ir jų procentas sumažėjo.

Aptarimas ir išvados. Neaptikome jokios koreliacijos tarp jaunų didelio meistriškumo krepšininkų aerobinio pajėgumo ir varžybinės veiklos rodiklių, o padidėjęs aerobinis pajėgumas neturėjo jokio poveikio daugumai tirtų kintamųjų. Dėl to tyrimo rezultatai rodo netiesinį ryšį tarp VO_2max ir krepšinio žaidimo rodiklių.

Raktažodžiai: aerobinis aktyvumas, krepšinio žaidimas, netiesinis ryšys.

Corresponding author **Carlos Claramunt Aguayo**
Institut Nacional d'Educació Física de Catalunya
University of Barcelona, Spain
Can pujolet street, 19-21, 2nd 1st. CP: 08032
Barcelona
Tel 610878083
E-mail carlostortosa21@hotmail.com

HEART RATE RECOVERY CHANGES DURING COMPETITION PERIOD IN HIGH-LEVEL BASKETBALL PLAYERS

Audrius Gocentas[1], Anatoli Landõr[2], Aleksandras Kriščiūnas[3]
State Research Institute Centre for Innovative Medicine[1], Vilnius, Lithuania
Department of Sports Medicine & Rehabilitation, University of Tartu[2], Tartu, Estonia
Lithuanian University of Health Sciences[3], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Replete schedule of competitions and intense training are features of contemporary team sports. Athletes, especially the most involved ones, may not have enough time to recover. As a consequence, aggregated fatigue can manifest in some undesirable form and affect athlete's performance and health.

Research aim. The aim of this study was to evaluate the changes in heart rate recovery (HRR) and investigate possible relations with sport-specific measures of efficacy in professional basketball players during competition season.

Research methods. Eight male high-level basketball players (mean ± SD, body mass, 97.3 ± 11.33 kg; height 2.02 ± 0.067 m, and age 23 ± 3.12 years) were investigated. The same basketball specific exercise was replicated several times from September till April during the practice sessions in order to assess the personal trends of HRR. Heart rate monitoring was performed using POLAR TEAM SYSTEM. Investigated athletes were ranked retrospectively according to the total amount of minutes played and the coefficients of efficacy.

Research results. There were significant differences in the trends of HRR between the investigated players. The most effective players showed decreasing trends of HRR in all cases of ranking.

Discussion and conclusions. Research findings have shown that the quality of heart rate recovery differs between basketball players of the same team and could be associated with sport-specific efficacy and competition playing time.

Keywords: adaptation, autonomic control, monitoring training.

INTRODUCTION

Heart rate (HR) is one of the most usable physiological variables in applied conditioning (Achten, Jeukendrup, 2003). HR monitoring was ranked as a moderate and objective method for the assessment of physical activity (Westerterp, 2009). HR can be measured frequently, inexpensively and noninvasively. The monitoring of HR allows the evaluation of HR recovery (HRR). After physical load HRR reflects the changes in the sympathovagal balance and has prognostic implications under a broad range of exercise conditions (Lahiri et al., 2008). Indices of HRR have been proposed in attempt to monitor and control the changes in the training status (Baumert et al., 2006; Buchheit, Gindre, 2006; Perini et al., 2006; Borressen, Lambert, 2008, Lamberts et al., 2009; Ng et al., 2009). The number of heart beats recovered during 1 min after cessation of exercise

is the simplest and frequently used HRR index associated with reactivation of parasympathetic activity (Cole et al., 1999; Shetler et al., 2001; Lahiri et al., 2008).

The depiction and monitoring of the training status as well as laboratory simulation of some specific activities for intermittent team game representatives was always a challenge in the field of applied physiology. The amount of scientific data on physiological responses in high-level team sport athletes is still limited because of limited accessibility to high-level athletes, the necessity to implement the monitoring without any influences on the training process and the specific features of team sport games. High variability of training content is associated with limited possibility to find some comparable activities during training sessions, when monitoring of some physiological variables is planned in basketball. The longitudinal effects of training on HRR were studied in several studies (Yamamoto et al., 2001; Perini et al., 2006; Lamberts et al., 2009) but seldom in team game and never in basketball athletes. Despite the individualization of training in accordance with the playing position, the playing time could be the most influencing factor when exertion or total physical bout are compared between athletes in the same team. We tested our hypothesis that possible modifications of the cardiovascular autonomic control occurring in basketball players over the competitive season are associated with the playing time and sport-specific efficacy.

The aim of this study was to investigate the changes in HRR during basketball season and reveal relations between them and sport-specific measures for attainment of efficacy in high level athletes.

RESEARCH METHODS

Subjects. Eight well-trained male basketball players participated in the study. All subjects followed the same structured training programme that included training sessions, competition games and days of rest. The research participants were involved in two competition frames, National championship and European Cup for clubs. The study design and the procedures were used in accordance with the ethical standards and the Declaration of Helsinki.

Design. The basketball-specific exercise applied in this study was described in our previous research (Gocentas, Landõr, 2006). This activity

continued for 3.5 minutes until it was stopped by the audio signal. The exercise described was always executed in the last part of the practice session. We selected four consecutive practices sessions that included basketball-specific 3.5-minute shooting exercise. All the analysed practice sessions were held in the morning. The intervals between the selected practice sessions were from seven to eleven weeks. In the current research, we analysed HRR immediately after the cessation of the described exercise. HR was monitored using downloadable, frequency-coded heart rate monitors (Polar TEAM SYSTEM) with 5-second registration intervals. We extracted values of the HR on the peak of sport-specific exercise (HR_{peakE}), and the values of the HR 60 s after the cessation of the exercise ($HR_{post60s}$). HRR was calculated as subtraction of abovementioned values ($HRR = HR_{peakE} - HR_{post60s}$). Individual trends of HRR were constructed for each athlete using HR data from the files of practices performed in the preseason, beginning, middle and the end of basketball season.

The data regarding playing time and individual efficacy are available on the official internet sites of the Lithuanian Basketball League and the Union of European Leagues of Basketball. The coefficient of efficacy is a cumulative value of all beneficial and harmful actions (missed and made shots, rebounds, fouls, blocks, assissts etc.) executed by a player during his playing time. Each beneficial action adds one point but each harmful action subtracts one point. The investigated athletes were ranked retrospectively according to the total amount of the minutes played and the coefficients of efficacy in both tournaments.

Statistics. The data are presented as means and standard deviations (SD). All statistics were calculated with the SPSS 11.0 (SPSS Inc, Chicago, USA) software package.

RESEARCH RESULTS

The descriptive data of the athletes are presented in Table 1. The trends of HRR after the sport specific exercise repeated several times during real practices are presented in Figure 1. Individual ranges of fluctuation in HR_{peakE} and $HR_{post60s}$ are shown in Table 2. The individual HR responses during the analysed sport-specific exercise showed a satisfactory repeatability. The fluctuations in HR_{peakE} were less expressed compared to $HR_{post60s}$.

Variable \ Values	Minimum	Maximum	Mean	Standard error	Standard deviation
Age, years	20	30	23	1.1	3.12
Stature, m	1.92	2.10	2.02	2.38	6.74
Body mass, kg	80	110	97.31	4.01	11.33
BMI, kg / m^2	21.68	25.18	23.75	0.44	1.25
VO_{2peak}, mL · kg^{-1} · min^{-1a}	39	57.90	47.35	2.24	6.32
VE, L · min^{-1a}	109.8	168.90	133.8	7.78	22.01

Table 1. Descriptive characteristics of the investigated athletes

Note. [a] – VO_{2peak} and VE were measured during graduated exercise test using VMAX (Sensormedics Inc., Yorba Linda, USA) gas analyser in laboratory enviroment. BMI = body mass index, VO_{2peak} = peak oxygen consumption, VE = minute ventilation.

HR \ Athletes	ATHL_1	ATHL_2	ATHL_3	ATHL_4	ATHL_5	ATHL_6	ATHL_7	ATHL_8
ΔHR_{peakE}	16	14	6	17	6	8	9	4
$\Delta HR_{post60s}$	15	18	28	16	39	29	12	45

Table 2. Individual fluctuations in heart rate on the peak of sport-specific exercise and 60 s later

Note. ΔHR_{peakE} = the highest variation in HR_{peakE}; $\Delta HR_{post60s}$ = the highest variation in $HR_{post60s}$.

Athletes \ Ranks	t_{EC}, min	Rank$_{tEC}$	t_{NC}, min	Rank$_{tNC}$	eff$_{EC}$	Rank$_{effEC}$	eff$_{NC}$	Rank$_{effNC}$
ATHL_1	426	1	915	2	13.8	2	11.29	3
ATHL_2	133	5	741	7	5.3	5	10.86	4
ATHL_3	22	8	440	8	2.3	7	3.45	8
ATHL_4	378	2	924	1	16.7	1	13.22	1
ATHL_5	111	6	904	3	3.2	6	11.44	2
ATHL_6	76	7	818	5	2.1	8	5.68	7
ATHL_7	270	3	812	6	6.1	4	7.57	6
ATHL_8	263	4	860	4	6.8	3	9.15	5

Table 3. Ranks of investigated athletes based on playing time and sport-specific efficacy

Note. t_{EC} = total playing time in European Cup matches; t_{NC} = total playing time in National Championship matches, eff$_{EC}$ = coefficient of efficacy in European Cup matches; eff$_{NC}$ = coefficient of efficacy in matches of the National Championship. ATHL_1… ATHL_8 = investigated athletes.

Each player in each frame of the competition ranked according to the time played and to the coefficient of efficacy. The differences in the playing time and efficacy between the players are reported in Table 3. Despite the category of the evaluation, the individual ranks of investigated players were stable enough. We can also observe that in all cases of ranking the athletes ranked as the first and the second demonstrate descending trend of HRR. The athlete ranked as the last has ascending HRR trend in all cases of ranking. The ranks of efficacy in the domestic league fully coincide with the HRR trends: four most effective players show descending trends but four less effective players have demonstrated ascending trends of HRR.

DISCUSSION

This is the first study investigating changes in sympathovagal balance during the whole season in basketball. The results have shown that trends in HRR differ in the investigated subjects. Large interindividual variability of responses was observed for both direction of trend and grade of inclination. Different changes in HRR during the period of observation suggest that the quality of recovery differs in high-level basketball players. The presented findings can be interpreted as indicators of insufficient recovery in some athletes. In contrast, the ascensional character of other trends toward pre-season levels could be considered as an indicator of the adequate recovery.

Figure. **Individual trends in HRR of the investigated athletes**

Note. ATHL_1… ATHL_8 = investigated athletes; HRR (bpm) = heart rate recovery measured in beats per minute. Points represent actual values, solid line and dashed line represent linear and logarithmic trend respectively. 1,2,3,4 = Results of measures in September, November, January, and April, respectively.
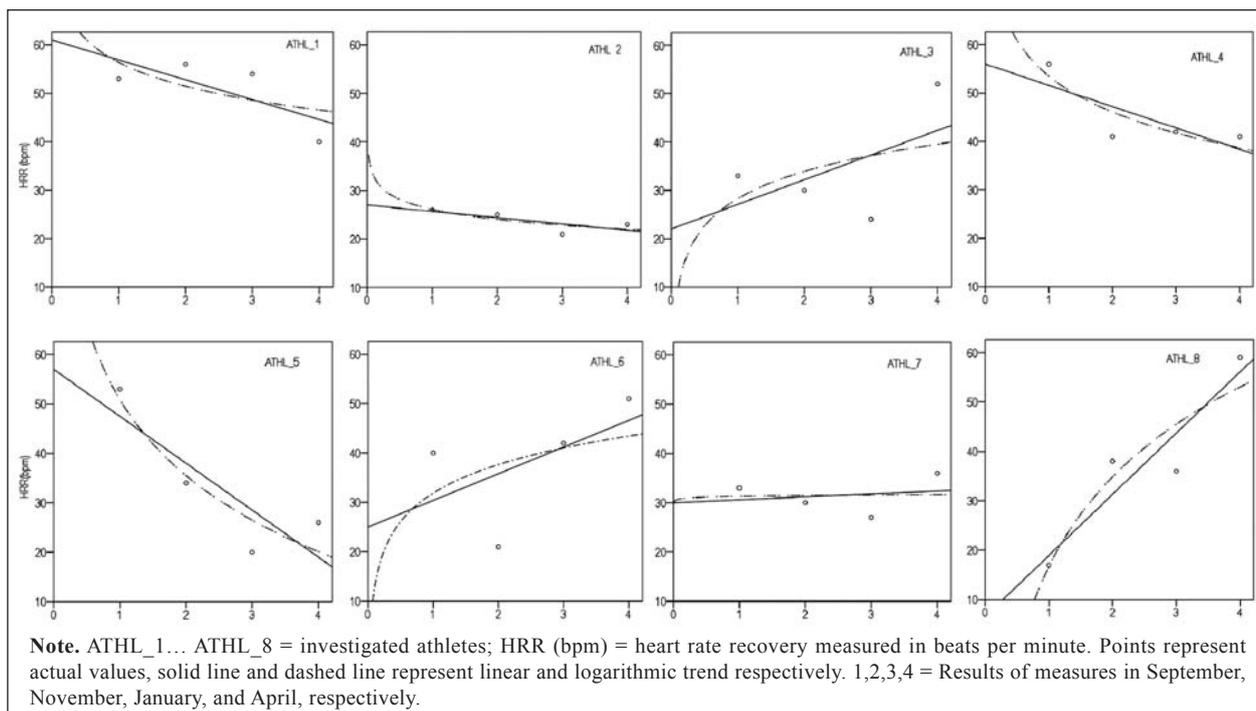
The described differences could be explained by individual threshold above which further training impulses do not improve the cardiorespiratory fitness of athletes (Kiviniemi et al., 2007). Altered autonomic cardiovascular control can be a sign of overtraining (Achten, Jeukendrup, 2003, Baumert et al., 2006), but we could not confirm the presence of overtraining in part of our athletes referring to just one separate index. The content of practice sessions in basketball varies day-by-day regarding the vision of the coaching staff and is associated with the current aims of the team. Despite it and the individualised training process, the main cause of the distinction in the executed exertion is a disparity in the playing time. The playing time alone cannot precisely describe the executed exertion during physical activity, especially when the nature of activity is not cyclical. The ranks of efficacy did not reflect physical efforts or the executed exertion directly. The values of the efficacy are tools to assess the quality of sport-specific technical variables but sufficient playing time is necessary to collect positive points for a high coefficient of efficacy. Playing five is decided by the team coach in basketball. The coach selects the players depending on the situation and many other factors. The principles of such a selection are not the point of interest in the current study, but our results clearly confirm that cardiac autonomic control of the most effective players falls down during the

course of the season because players ranked as the first and second have shown descending trends of HRR after a sport-specific exercise in all the cases of ranking. Simultaneously, the player ranked as last had ascending trend of HRR after a sport-specific exercise in all the cases of ranking.

T. Otsuki et al. (2007) showed that both strength- and endurance-trained athletes have improved their heart rate recovery after 8 min of steady-state exercise at 40% of maximal oxygen uptake compared to untrained controls. The training process in basketball is a composite and complicated matter. Besides the efforts to develop strength, power and endurance, the tactical and technical individual and team activities take much time during practice sessions. Furthermore, athletes take part in1-3 games each week. So, different HRR dynamics in individual athletes were evoked by unequal responses after the executed loads. Individualised loads during the practice sessions promote the process of recovery. Immoderate or oversized loads rise an overstrain of regulatory mechanisms (Baumert et al., 2006; Kiviniemi et al., 2007). The deceleration of recovery could be expression of such unbeneficial status. Thus, the dynamic assessment of the quality of recovery allows detecting individual capacity to tolerate the proposed and executed physical loads. Training impulse and playing time are important but not the sole factors influencing recovery. The practical questions are when a particular

subject reaches this limit, how to recognize it, and what options we have to manage such situations. M. Buchheit et al. (2010) suggested the existence of a common genetic denominator responsible for the function of the autonomic nervous system and aerobic performance. So, in our previous study (Gocentas, Landõr, 2006) the relations between HRR and aerobic capacity were shown in high- level basketball. Despite this, we used individual values of VO_{2peak} only for the description of involved subjects in the current study, because the measurement of this variable was performed on a one-off basis, at the beginning of the observation.

The findings in the current report are based on longitudinal short-term episodes. Our choice to analyse this short-term exercise was conditioned by the specificity of practice sessions in basketball. Its main challenge when monitoring some physiological variables in basketball is planned to find some comparable activities in particular training sessions. In the previous study we described and analysed a basketball-specific 3.5-minute shooting exercise (Gocenta, Landõr, 2006). This choice was based on the appropriate features of the above-mentioned exercise. Namely, the exercise had even duration and was always performed as the last exercise of the morning practice session, the athletes were always motivated by their coaches. The validity of analysing short-term recordings was confirmed earlier (McCraty et al., 1995; Ng et al., 2009). Moderate intraindividual ranges of HR_{peakE}, as shown in Table 2, indirectly support the tolerable repeatability of the analysed exercise. The number of investigated athletes is the main limitation of this study but high-level athletes form just a small part of the community, and often studies of competitive athletes come across a similar problem. So, scarce statistical methods are also associated with the same reason. Despite that, single subject research is recommended in the field of applied conditioning research (Kinugasa et al., 2004).

CONCLUSSIONS AND PERSPECTIVES

In conclusion, our findings provide longitudinal data about changes in sympathovagal balance in the presence of the high-level stress. Our results show that the use of the Polar monitor during practice sessions in high-level basketball can provide a HRR analysis in a useful, non-invasive and inexpensive way for evaluating the functional status of athletes.

The sport-specific analysis is proposed as a technique for complementing the evaluation of the functional state of athletes for enabling strategies that can be directed towards the optimization of the impact of the training process on performance. However, the underlying mechanisms still need to be more exactly revealed in the future research.

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DIDELIO MEISTRIŠKUMO KREPŠININKŲ ŠIRDIES ATSIGAVIMO KAITA VARŽYBŲ LAIKOTARPIU

Audrius Gocentas[1], Anatoli Landõr[2], Aleksandras Kriščiūnas[3]
Valstybinio mokslinių tyrimų instituto Inovatyvios medicinos centras[1], Vilnius, Lietuva
Tartu universitetas[2], Tartu, Estija
Lietuvos sveikatos mokslų universitetas[3], Kaunas, Lithuania

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Šiuolaikiniam sportui būdinga varžybų gausa ir intensyvios pratybos. Toks intensyvus tvarkaraštis gali turėti įtakos sportininkų atsigavimui, sudaryti sąlygas nuovargiui atsirasti. Darome prielaidą, kad krepšininkų krūvio skirtumas per metinį rengimo ciklą susidaro dėl labai skirtingos žaidimo trukmės, tenkančios atskiriems atletams. Toks nevienodumas galėtų lemti atsigavimo kokybę, ir tai parodytų širdies autonominės reguliacijos rodiklių kaita.

Tikslas: įvertinti širdies atsigavimo kaitą ir ištirti galimą ryšį su sporto šakos specifiškumu.

Metodai. Buvo tiriami aštuoni didelio meistriškumo krepšininkai. Jie dalyvavo Lietuvos pirmenybių ir Europos taurės turnyruose. Širdies susitraukimų dažnis buvo registruojamas realių pratybų metu „Polar Team System" pulsomačiu ir programine įranga. Analizei atlikti parinktas specifinis sporto šakos pratimas, kurio pulsogramomis buvo naudotasi retrospektyviai analizuojant atsigavimą.

Rezultatai. Individualūs žaidėjų ŠSD atsigavimo kryptingumo grafikai parodė nevienodą krepšininkų atsigavimo kokybę per metinį rengimo ciklą. Žaidėjus surangavus pagal vidutinį abiejų turnyrų žaistų minučių kiekį ir veiksmingumo koeficientus, žemėjantis ŠSD atsigavimo kryptingumas pastebėtas tarp daugiausia laiko žaidžiančių ir didžiausius veiksmingumo koeficientus turėjusių krepšininkų. Visais rangavimo atvejais krepšininkas, esantis rangų lentelės apačioje, turėjo kylantį ŠSD atsigavimo kryptingumo grafiką.

Aptarimas ir išvados. Širdies autonominės reguliacijos rodiklių kaita parodė, kad daugiausia ir naudingiausia žaidusių krepšininkų atsigavimo kokybė per metinį rengimo ciklą blogėja. Į tai turėtų būti atsižvelgta planuojant treniruotės vyksmą. Rezultatai patvirtina autonominės širdies reguliacijos rodiklių tinkamumą sportininkų funkcinei būklei stebėti.

Raktažodžiai: adaptacija, autonominė kontrolė, treniruotės vyksmo stebėsena.

Corresponding author **Audrius Gocentas**
State Research Institute Centre for Innovative Medicine
Žygimantų str. 9, LT-011002 Vilnius
Lithuania
Tel +370 52619161
E-mail audrius.gocentas@ekmi.vu.lt

ANALYSIS OF COMPETITIVENESS IN THE NBA REGULAR SEASONS

Yves de Saá Guerra, Juan Manuel Martín González, Nieves Arjonilla López, Samuel Sarmiento Montesdeoca, David Rodríguez Ruiz, Juan Manuel García Manso
University of Las Palmas de Gran Canaria, Canary Island, Spain

ABSTRACT

Research background and hypothesis. Several attempts have been made to understand some modalities of sport from the point of view of complexity. Most of these studies deal with this phenomenon with regard to the mechanics of the game itself (in isolation). Nevertheless, some research has been conducted from the perspective of competition between teams. Our hypothesis was that for the study of competitiveness levels in the system of league competition our analysis model (Shannon entropy), is a useful and highly sensitive tool to determine the degree of global competitiveness of a league.

Research aim. The aim of our study was to develop a model for the analysis of competitiveness level in team sport competitions based on the uncertainty level that might exist for each confrontation.

Research methods. Degree of uncertainty or randomness of the competition was analyzed as a factor of competitiveness. It was calculated on the basis of the Shannon entropy.

Research results. We studied 17 NBA regular seasons, which showed a fairly steady entropic tendency. There were seasons less competitive (≤ 0.9800) than the overall average (0.9835), and periods where the competitiveness remained at higher levels (range: 0.9851 to 0.9902).

Discussion and conclusions. A league is more competitive when it is more random. Thus, it is harder to predict the final outcome. However, when the competition is less random, the degree of competitiveness will decrease significantly. The NBA is a very competitive league, there is a high degree of uncertainty of knowing the final result.

Keywords: complex systems, basketball, entropy, competition, randomness.

INTRODUCTION

The degree of equality of the playing strengths of teams, competitive degree or competitive balance, is a central concept in the analysis of professional sports leagues. There is considerable interest in tracking movements in competitive balance over time and analysing the effects of regulatory, institutional and other changes, as indicated by the extensive literature on the subject in several sports (Schmidt, Berri, 2001; Fort, Maxcy, 2003; Rhoads, 2004; Goossens, 2006).

Most studies deal with this phenomenon with regard to the mechanics of the game itself (Chatterjee, Yilmaz 1999; McGarry et al., 2002; Lebed 2006; McGarry, Franks, 2007; Passos et al., 2008, Passos et al., 2009), nevertheless, few

studies do that from the perspective of competition between teams in differents sport (Malacarne, Mendes, 2000; Yilmaz, Chatterjee, 2000; Onody, de Castro, 2004; Mendes et al., 2007; Vaz de Melo et al., 2008; Ribeiro et al., 2010).

The aim of our study was to assess the degree of competitiveness on the basis of the uncertainty level that might exist for each confrontation. We calculated the value of the Shannon entropy which quantifies the information contained by a variable (Shannon, 1948; Robert, 1965; Yeung, 2008), to determine the degree of uncertainty or randomness of the competition.

We can understand the team as a complex systemic unit and the competition – as the emerging enviroment (Gréhaigne et al., 1989), a direct reflection of the nature of the teams and their critical interactions. Herein lies the importance of knowing the behavior of the environment, its relationship and impact on a team as a complex system. The performance of a team is the result of synchronous interaction of certain optimization of its component systems, they are also a reciprocal relationship with the competition, the emerging and critical environment.

The competitive model (type of confrontation) has a direct impact on competition, development and evaluation. Such small changes can alter the outcome, given the close relationship between the competitive model and competition (Lebed, 2006).

Given the difficulty of predicting results of the games, and therefore, the final qualification, we must not use linear methodology for analysis. It is necessary to use a methodology that allows us to explore the nature of the competition with as much detail as possible, as is the theory of complexity.

In complex systems, the processes which occur simultaneously at different scales or levels are important, and the intricate and complex behavior of the system as a whole depends on its units.

Although not directly, the structures of complex systems are powerfully related, and often non-linearly (Goodwin, 2000; Vicsek, 2002; Solé, 2009). The chaos theory has been proved to be an adeguate tool to observe all these seemingly incomprehensible or random systems. Usually natural systems are chaotic.

A league is more competitive when there is more randomness. In fact, this means that the harder it is to predict the final outcome, the tougher the competition will be. Since all teams have a similar performance level, any small change will lead to an imbalance. However, when the competition is less random, the degree of competitiveness will decrease significantly, therefore, we have a competition where there are great opportunities to know the final outcome.

RESEARCH METHODS

The aim of our study was to analyze the level of competeveness in sport competitions. We studied the results obtained from the North America Professional Basketball League [National Basketball Association] (NBA), 1992/93 to 2008/09 seasons.

Generally, in any official competition, different teams play the same number of games at home and away; showing a confrontation matrix with the same numbers of rows and columns: points scored, wins, losses, points scored and points against. For N teams, there is a matrix of size N x N. See Figure 1 for an example of the matrix N = 4.

The vector R (score vector) represents the results obtained by each team in each season, while the number of games won Ri divided by the number of games played by each team, or ratio (number of wins / number of games played) has the sense of probability.

The result vector R, at first, behaves randomly, in the sense that we do not know the final result,

Figure 1. **Example of a matrix N = 4**

	a	b	c	d	HW	R
a	x	1	0	1	2	4
b	0	x	0	0	0	1
c	1	1	x	1	3	5
d	0	0	1	x	1	2
AL	1	2	1	2	x	
	2	1	2	1		

Note. The rows represent the games played by a team at home. The columns represent the won or lost games played by a team away. HW (Home Won games) represents the total number of games won by the teams at home. AL (Away Lost) is the lost games away. AW represents the total number of games won away. The final score R is the sum of the home and away victories, R = HW + AW, AW = (N – 1) – AL

but the results of the previous seasons (historical performance) may provide some clues. The values of R historical or previous seasons divided by the sum of all games can also be considered as a discrete probability distribution:

$$p_i = \frac{R_i}{\sum\limits_{j=1}^{N} R_j}$$

Where p_i indicates the probability that the i team gets a certain result and therefore can be considered as a performance indicator.

In the case of uniform distribution, any team has an equal chance of winning. In terms of statistical mechanics, such distributions are related to equilibrium situations where all structures and gradients have been eliminated. The disorder is maximum therefore; the values of entropy (S) are also maximum.

When the set of probabilities of a system is known, we can define the Shannon entropy (S), which is an average measure of uncertainty and, hence, refers to the average amount of information that contains a random variable. It is defined as:

$$S = \sum_{i=1}^{N} \left(p_i \log {1}/{p_i} \right)$$

The value of S changes with the value of N, number of teams, and therefore are not comparable in different seasons if the number of teams changes. Thus, it is preferable to use the normalized entropy (Sn):

$$Sn = \frac{S}{\log(N)}$$

So the maximum value of Sn is bounded between 0 and 1, where 1 corresponds to the situation in which all values are equal to each other.
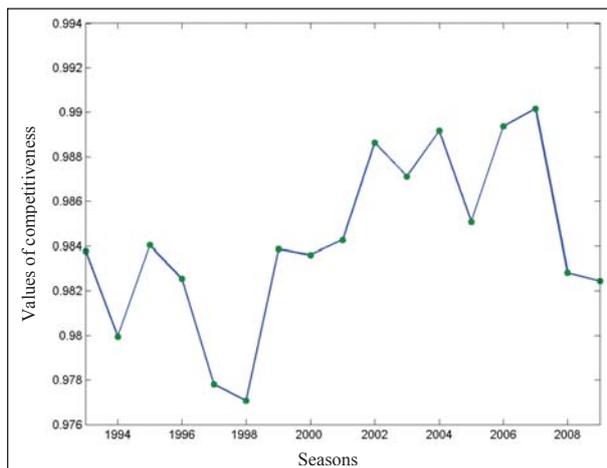
We can express the result table as a set of probabilities, and we can calculate the value of Sn and obtain a parameter that will measure by what extent the system is more or less away from the equilibrium. If we define the equilibrium state as the situation of maximum competitiveness, the Sn value provides a numerical value of competitiveness for a given season. From this point of view, if a competition is less random, the degree of competitiveness is lower, which means that we have a competition with less uncertainty about the final result.

RESEARCH RESULTS

The NBA has a much more stable entropic tendency. There are seasons less competitive (≤ 0.9800) than the overall average (0.9835), and periods where the competitiveness remains at higher levels (range: 0.9851 to 0.9902) (Figure 2). We can clearly see the seasons that do not correspond to this trend, showing a behavior that can be defined as "anomalous" compared to the rest of the trend shown. These seasons are: 1993–1994, 1996–1997, 1997–1998 and the period between 2001–2002 and 2006–2007 seasons.

DISCUSSION

The NBA is a league of closed structure (no promotions and relegations), which is composed of thirty 30 franchised member clubs, twenty-nine of which are located in the United States and one in Canada. The current league organization divides thirty teams into two conferences of three divisions with five teams in each. The current divisional alignment was introduced in the 2004–2005 season. During the regular season, each team plays 82 games, 41 at home and 41 away.

Figure 2. **The seventeen NBA seasons analyzed**

Note. The y-axis represents the values of entropy (from 0, less competitiveness, to 1, high competitiveness). Entropy of NBA remains stable and close to its average values, showing two diferent periods to this trend. The first one from 1995–1996 season to 1998–1999 season. The second one from 2000–2001 to 2006–2007.

A team faces opponents in its own division four times a year (16 games); teams from the other two divisions in its conference either three or four times (36 games); and teams in the other conference twice respectively (30 games). This asymmetrical structure means that the strength of schedule will vary significantly between teams.

The NBA is a franchise-type business model where each team owns rights to their players. In this manner, you can make transfers between franchises, without the player being involved in the operation. Besides, the free agent also exists within limited entrepreneurial skills and regulations.

At the NBA there are economic and player factors that could generate anomalous competitions and unusual results. For example, we observe that during the seasons 1995–1996, 1996–1997 and 1997–1998, Michael Jordan's Chicago Bulls, obtained the best records of wins at the NBA regular season so far (win-lost: 72–10, 69–13 and 62–20 respectively). This monopoly period is probably responsible for the decline in competitiveness at the league, and it is also accompanied by an increased attraction to athletes and the public, as well as private companies and media, resulting in a strong economic impact. It has been estimated that since the arrival of Michael Jordan until his second retirement, the economic impact was about 90 000 million Euros (Escudero, 2007).

Another interesting area covers the period 2001–2002 to 2006–2007 seasons. These correspond with the renegotiation of the salary cap (1999–2005) when the Collective Bargaining Agreement (CBA) was signed. Probably, that fact had an impact on the overall performance of the league, due to the fact that the objective of the salary cap is to prevent teams with large surplus of profits, and it can be signed by the best players available; thereby, facilitating the retention equality in the league. This mechanism, together with the draft, is necessary for each franchise to carefully select which players may be interested in the market for its project (depending on the background of the team). Consequently, each franchise only achieves to "shield" economically one or two players, commonly referred to as "franchise players".

If we consider the team as a complex system, we must bear in mind that one of the defining features of complex systems is the difficult to predict beyond a certain timeframe, and high dependence on initial conditions. But this does not mean that prediction is impossible. The memory of initial conditions is lost within the attractors, as the teams are within the competition, their emerging and chaotic environment. But the attractor itself can be extremely robust. In particular, chaotic does not mean unstable. Chaos means that simple systems can produce complex responses. It is clear that there is nonlinear dynamics alone alive (Amaral et al., 2004).

We must remember that complex systems are usually out of balance. For instance, living organisms are in a constant struggle with their environment to stay in a particular state of equilibrium, i. e. alive (Amaral et al., 2004). In our context, it would mean that to maintain this level of competition so high, it is necessary for a team to be in constant struggle to overcome rivals, and invest huge amounts of energy to survive the competition.

CONCLUSIONS AND PERSPECTIVES

In conclusion, we can state that the analysis model (Shannon entropy) for the study of the levels of competitiveness in the system of league competition, is a useful and highly sensitive tool to determine the degree of global competitiveness of a league and to detect small oscillations. The potential to detect minimum fluctuations at the level of competition allows us focusing attention on localized temporal changes and investigating the mechanisms which cause them.

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NBA REGULIARAUS SEZONO VARŽYMOSI LYGMENS ANALIZĖ

**Yves de Saá Guerra, Juan Manuel Martín González, Nieves Arjonilla López,
Samuel Sarmiento Montesdeoca, David Rodríguez Ruiz, Juan Manuel García Manso**
Gran Kanarijos las Palmas universitetas, Kanarų salos, Ispanija

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Skirtingą sporto ekspertų daugiaplanio rungties struktūrinio modelio analizę lemia skirtinga jo samprata. Problema ta, kad dauguma mokslo darbų šį fenomeną studijuoja izoliuotai – analizuodami tik paties sportinio žaidimo struktūrą. Tačiau kai kurie tyrėjai šį fenomeną sieja su varžymosi aplinka. Komanda suprantama kaip sudėtingas kompleksinis sisteminis vienetas ir jam funkcionuoti būtina sąlyga yra varžybos. Tik varžybos sudaro prielaidą grupei tapti sportine komanda.

Taikytas *Shannon* entropijos analizės metodas leidžia ne tik nustatyti ir įvertinti komandų bendrąjį varžymosi lygmenį, bet tiksliai nustatyti ir jo kaitą.

Tikslas: sukurti sportinių žaidimų komandų varžymosi lygmens analizės modelį.

Metodai. Buvo taikyta sporto varžybų – neapibrėžtumo arba atsitiktinumo kriterijų – laisvės laipsnio analizė. Laisvės laipsnis buvo skaičiuojamas pagal *Shannon* metodą.

Rezultatai. Taikant šį modelį tirta 17 reguliarių NBA sezonų. Pastebėta gana stabili entropijos tendencija. Pasitaikė mažesnio varžymosi (≤ 0,9800), lyginant su vidurkiu (0,9835), ir didelio varžymosi (nuo 0,9851 iki 0,9902) lygmens sezonų.

Aptarimas ir išvados. Didesnis varžymosi lygmens atsitiktinumų laisvės laipsnis lemia NBA lygos komandų varžymosi laisvės laipsnį. Atskirų rungtynių baigties rezultatai neprognozuojami. Kita vertus, mažėjant varžymosi lygmens laisvės laipsniui, mažėja rungtynių baigties lygmens laisvės laipsnis, taip pat reikšmingai sumažėja konkurencingumas.

Galima daryti išvadą, kad NBA yra labai konkurencinga lyga. Rungtynių baigties neapibrėžtumo laisvės laipsnis gana didelis.

Raktažodžiai: kompleksinės sistemos, krepšinis, entropija, varžybos, atsitiktinumas.

Corresponding author **Yves de Saá Guerra**
University of Las Palmas de Gran Canaria
Building of Educacion Fisica
35017 Canary Island
Spain
Tel +34 928 45 44 06
E–mail yvesdesaa@gmail.com

MOTOR LEARNING OF GROSS-MOTOR SKILLS UNDER VARIABLE PRACTICE CONDITIONS

Anita Haudum, Jürgen Birklbauer, Kröll Josef, Erich Müller
University of Salzburg, Salzburg, Austria
Christian Doppler Laboratory "Biomechanics in Skiing", Salzburg, Austria

ABSTRACT

Research background and hypothesis. For both the athlete and the coach, the purpose and goal of training is the same: to enhance performance.

Research aim. This study investigated the effect of differential learning on basketball free throw and volleyball strike.

Research methods. In the basketball experiment, in pre-, post- and retention test design, the free throw performance was measured (number of successful shots). Aiming to investigate transfer performance, jump shots were tested. In the volleyball experiment, movement variability during the strike was further increased by the application of an elastic constraint. The second intervention and quasi-control group trained under constant practice conditions. Ball velocity and accuracy were analysed with a constant and a variable test.

Research results. No significant differences were observed for either the free throw ($p > 0.05$) or the transfer performance ($p > 0.05$). However, a positive trend for the variable group was observed in the transfer situation. For the strike in volleyball, the differential learning group had a significant advantage with respect to velocity in a variable test situation ($p < 0.05$) whereas in the constant situation ($p > 0.05$) and measurements for accuracy ($p > 0.05$) it did not reveal similar results.

Discussion and conclusions. In both experiments, the set variability leads to benefits in variable (transfer) situations. However, as a practical consequence, especially for constant situations, certain moderator variables such as training age or background in other sports or activities must be kept in mind to adjust the amount of external or intervention-induced variability.

Keywords: differential learning, variability, adaptability, ball sports.

INTRODUCTION

For both the athlete and the coach, the purpose and goal of training is the same: to enhance performance. In human movement science and motor learning, various (theoretical) approaches and concepts that incorporate different forms of variable practice (e. g., Schema theory or differential learning) and task arrangements (i. e., constant, blocked variable or random) have been developed and investigated (Brady, 2004; Schöllhorn et al., 2009 a). In recent years, the integration of other (physiological and non-physiological) approaches – all focusing on variability – such as synergetics or dynamic system approaches, stochastic resonance, neurobiology, as well as artificial neural network simulations also emphasized the important role of variability in motor development and learning (e. g., Button et al., 2003; Schöllhorn et al., 2009 a, b). Consequently, the ambition to increase performance

and to form an adaptable and flexible athlete has increasingly drawn attention to the advantage of variable training.

In addition to the abovementioned approaches, one approach that integrates the ideas of Russian neurophysiologist and movement pioneer Nikolai Bernstein (1967) is the differential learning approach by W. Schöllhorn et al. (2009 a). In differential learning, the athlete should explore and discover the individual optimum through self-organizing processes following enhanced fluctuations. These fluctuations, due to optimal perturbations within the organism, provoked by a noisy training environment, lead to movements seen as deviations from the task to-be-learned. The different executions should guide the learner towards his / her most effective movement co-ordination pattern. When the athlete has to adapt to force, the choice and order of exercises should be arranged in a way that no adaptation process would resemble an other one. Research showed similar, if not better performances than training methods typical for their sports, as well as constant practice or methodological rows (e. g. Schönherr, Schöllhorn, 2003; Birklbauer et al., 2006; Spratte et al., 2007).

To further test the idea of differential learning, we conducted two studies in complex sports on two different levels of play. In a study on the basketball free throw, we compared differential learning to standard training at different skill levels (13-year- to 16-year-olds). Our second experiment examined the volleyball strike. Participants were elite volleyball players and, as it is assumed that the strike technique is already matured on this level of play, movement variability within the movement task was further provided by using a special training device with elastic cords.

RESEARCH METHODS

Experiment 1. Fifty three youth basketball players (n = 52 males and 1 female; junior and under-16 basketball players; mean age: 14.3 ± 0.9 years, mean training age: 4.8 ± 1.3 years; top national youth level) practiced the free throw. Players were assigned either to one of the two intervention groups or a control group (CG) in a quasi-random manner based on their pre-test performance (successful and missed shot ratio). Each group consisted of 17 players whereby the number of players with respect to the skill level was counterbalanced across all groups.

Research Design. Intervention group 1 (IG1-BB) trained according to the differential learning approach whereas intervention group 2 (IG2-BB) practiced according to standard, constant free throw training. Participants completed 15 sessions and performed 50 free throws each session (without augmented feedback) over a period of 7.5 weeks (additional to the regular training). Pre-, post- and retention tests were done to measure free throw performance. In addition to counting the successful and missed free throws for a total of 20 test shots, all shots were rewarded according to a special point system (following D. Memmert (2006)): zero points for a missed shot; one point for a missed shot that touches the rim just once; two points for a missed shot that touches the rim more than once; four points for a successful shot that touches the rim; and five points for a successful "nothing but net" shot. The calculated sum was another parameter to estimate performance. On post- and retention test time points, transfer tests (TT) were done in which 20 jump shots with three dribbling prior to the jump were executed from a shooting position that was 45° right from the basket / board just behind the paint. Alike, the hit shots were counted and were rewarded according to the point system.

For the differential group, each session focused on a different aspect of the throw movement (e. g., knee angle, release point, wrist motion). Variations included movement errors and deviations, respectively, of the goal movement. Examples would be 1) shooting with the knees remaining flexed; 2) shooting with extreme wrist-flexion; and / or 3) shooting with an increase in knee extension velocity. Likewise, invariants (common to the variability-of-practice-hypothesis) were not held constant but were varied, too. The variations not only concerned movement executions, but also the target. The constant practice group shot 50 free throws without any instructions.

Experiment 2. Fourteen active elite volleyball players (n = 6 men and 8 women; mean age: 23.7 ± 2 years, mean weight: 84.1 ± 6.5 kg, mean height: 193.2 ± 8.5 cm, mean training age: 6.3 ± 2 years) of top national volleyball league standard participated in the current study. Original sample size was 16; however, due to injury two players could not take part in the post test.

Research design. Players were assigned to one of the two intervention groups (i. e., seven players each) who practiced the strike over a period of 18 sessions (two sessions per week; 25 strikes each session) additionally to the regular training.

Intervention group 1 (IG1-VB) practiced according to the differential learning approach. In contrast to the first experiment, the intervention-induced variability was not only achieved by diverse executions but also by perturbations created through elastic cords (Figure 1a). Examples for such cord positions would be 1) from the left anterior superior iliac spine to the upper arm; 2) from left anterior superior iliac spine to the wrist and elbow; and 3) from the ilio-sacral joint to the upper arm and the left ball. Variability was further enhanced by the altering cord position and length.

Seventeen of the 25 strikes were practiced with cords; the remaining 8 strikes were practiced without cords. The second intervention and quasi-control group (IG2-VB) practiced their strikes according to constant practice. Pre- and post-tests consisted of one constant and one variable test situation in which the participants were told to strike at the given target as fast and accurately as possible. The four target positions used were equivalent to positions in volleyball (see Figure 1b). In the constant test situation, participants had to strike 10 shots at position 1. In the variable test condition, participants were required to strike a total of 16 shots at four predetermined targets in random order.

The training device (Tendybelt ®, Salzburg, Austria) is a specially designed chest belt tied around the waist with loops at the front and back and a hook-and-loop fastener at the front (Figure 1a). The cords used in this study were different thera tubes (*Thera-Band ® GmbH*, Dornburg-Frickhofen, Germany). The cords were used in order to increase variability in reactive phenomena within an optimal solution space.

Ball velocity and accuracy were measured to determine performance increase. Velocity was measured using an ALGE speed system (*ALGE Timing*, Lustenau, Austria). To measure accuracy, deviations were calculated according to a coordinate system. This coordinate system was virtually spanned over the entire volleyball court with the base line representing the y-axis and the side line as x-axis.

Statistical analyses. Statistical calculations for both experiments were performed using PASW 18 (SPSS Inc., Chicago, IL., USA). All significant differences reported were at $p < 0.05$. Data were checked for normality (Kolmogorov-Smirnov test), sphericity and reliability were calculated for the accuracy test in volleyball. Means and 95%-confidence intervals were calculated using conventional statistical measures. A two-way repeated measures analysis of variance (ANOVA) was employed to examine differences on each of the dependent variables. For the basketball experiment, a 3 (group) X 3 (time) ANOVA and for the volleyball experiment, a 2 (group) X 2 (time)

Figure 1 a. **Application of the elastic cords**

Note. The elastic cords were from the lower back to the right forearm and from the left hip to the right upper arm.

Figure 1 b. **Four targets and the subjects' striking position**
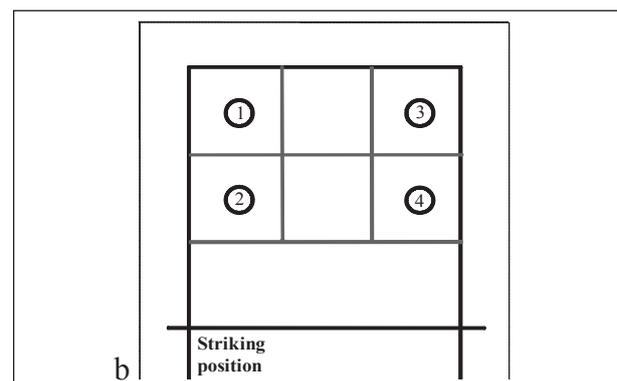
ANOVA were calculated. Independent variables for both experiments were group and time; dependent variables for the basketball experiment were successful shots and sum of points; for the volleyball experiment they were strike velocity and strike accuracy. Simple contrasts were calculated to reveal group differences. Effect size partial eta squared (η_{p^2}) was calculated to measure the degree of meaningfulness. Graphs were created using OriginPro 8.0 (*OriginLab Corporation*, Northampton, USA).

RESEARCH RESULTS

For the basketball experiment, similar results were found across the three groups for pre-, post- and retention tests. Data with respect to the sum of points showed no statistical differences among all three groups ($p > 0.90$; $\eta_{p^2} = 0.01$; Figure 2 a). Post hoc analyses for each age group (i. e., junior and under-16) demonstrated similar results with marginal, non-significant effects (junior: $p > 0.70$; $\eta_{p^2} = 0.04$; under-16: $p > 0.90$; $\eta_{p^2} = 0.03$). Simple contrasts between groups revealed no significant differences for sum of points (IG1-BB vs. CG: $p > 0.67$; $\eta_{p^2} = 0.01$; IG2-BB vs. CG: $p > 0.78$; $\eta_{p^2} = 0.01$; IG1-BB vs. IG2-BB: $p > 0.96$; $\eta_{p^2} = 0.00$).

Analysing the transfer test situations, performance was lower for all three groups compared to post free throw and retention free throw tests; however, the differences between the groups were not statistically significant (TT 1: $p > 0.80$; $\eta_{p^2} = 0.01$; TT 2: $p > 0.30$; $\eta_{p^2} = 0.05$). Additionally, the time X group interaction showed no significant results for the jump shot ($p > 0.20$; $\eta_{p^2} = 0.06$) (Figure 2 a). Otherwise, simple contrasts between groups revealed appreciable effects for the transfer situation comparison of IG1-BB versus CG, as IG1-BB showed superior performance ($p > 0.10$; $\eta_{p^2} = 0.09$). No such effects were found for the comparison of IG2-BB to CG ($p > 0.60$; $\eta_{p^2} = 0.01$) and the IG1-BB to IG2-BB ($p > 0.30$; $\eta_{p^2} = 0.03$). Results for successful shots show similar results as those for sum of points.

In the volleyball experiment, results unveiled a significant advantage with respect to velocity for the elastic cord group in variable situations ($p < 0.05$; $\eta_{p^2} = 0.36$), whereas constant situations did not reveal similar results ($p > 0.50$; $\eta_{p^2} = 0.03$) (Figure 2 b).

For the accuracy test, a reliability of 0.42 was found. Calculated results did not show significant differences for the constant or variable situation ($p = 0.05$; $\eta_{p^2} < 0.26$).

a
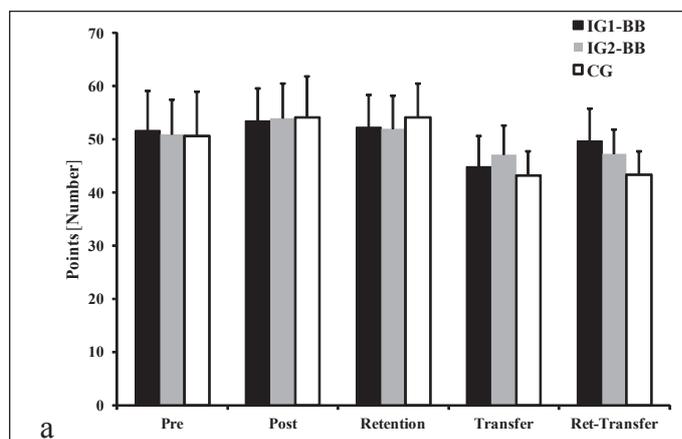
Figure 2 a. **Mean values for the sum of points for all three groups at all test times**

Note. * – indicates a significant increase in performance; ▲ – indicates difference between groups (error bars represent 95% – confidence interval).

b
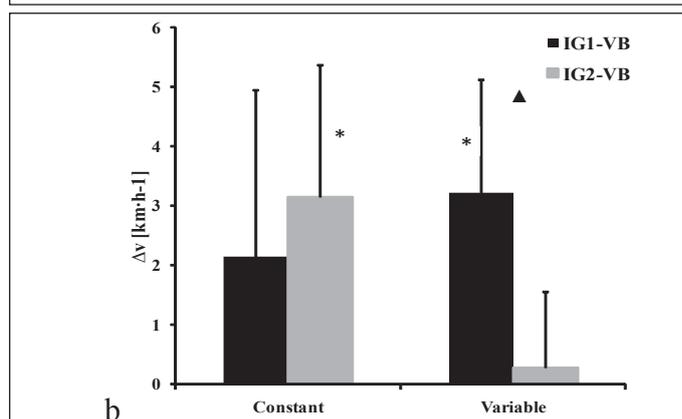
Figure 2 b. **Mean group changes for velocity in the constant (left) and variable (right) situation**

DISCUSSION

Summarizing the two experiments, differential learning shows advantages in variable and transfer situations, but constant training situations do not yield similar results.

The findings in the free throw experiment might be considered surprising given previous research on the same basketball skill (Schönherr, Schöllhorn, 2003), which demonstrated a performance advantage for differential learning after acquisition phase (participants were about the same age, however, they had a low level of performance).

Notwithstanding the above, results in transfer tests represent a small advantage for the intervention groups over CG. Calculating the percentage of transfer (PoT) (Magill, 2004), both IG1-BB and IG2-BB show a positive transfer compared to CG. In the first transfer test, IG2-BB demonstrates better transfer than IG1-BB (+2.6% for points and +5.3% for number of shots), but it was outperformed in the second transfer test by IG1-BB (+2.4% for points and 5.8% for number of shots), reflecting a continuous positive trend in performance increase in the transfer situation. This would be in line with the idea of different variable practice concepts where positive effects are observed on transfer tasks, and it may take until the retention test to observe an advantage in performance (Brady, 2004; Memmert, 2006; Schöllhorn et al., 2006; Schöllhorn et al., 2009 a).

For the volleyball strike, the intervention-induced variability through different cord applications resulted in a superior learning effect with respect to velocity in variable situations. In the constant test situation, both groups improved their performance, with the standard training group showing similar performance in strike velocity. As a reliability of 0.42 for the accuracy test is unqualified to fulfill the criteria to offer any particular information (Bortz, Döring, 2002), the results of the accuracy data will not be considered in the following discussion.

Nonetheless, the question to be answered is why variable practice in volleyball and basketball should lead to proficiency that outperforms constant practice in the long run not only in variable situations but in constant situations as well.

As such approaches as neurobiology or artificial neural networks illustrate, a central issue is the adaptation of the human nervous system and

the extraction of rules (i. e., generalization ability). Already during the very early stages of life, we learn due to our generalization ability. Babies neither learn to talk nor do they learn to walk or run by instructions (Adolph et al., 2003). Instead, their nervous system automatically extracts the underlying similarities and generalizes the experiences in such a way, that they learn to walk or talk without explicitly knowing the underlying "rules".

The same can be applied to skills in sports. Volleyball or basketball players do not acquire the same flexibility and adaptability of their strike / shot (adequate for the different situations occurring during the game) through constant repetition than through variable training. Rather, different stimuli permit the development of the required skill for the dynamic game situation. One must take into account that in volleyball and basketball no situation is alike because there is a rapid and permanent change due to different game situations and different opponents (Lames, McGarry, 2007). The acquisition of an appropriate "rule" that allows the best movement outcome for the actual situation (i. e., good generalization) should be ensured through diverse executions (Schöllhorn et al., 2009 a).

Concerning the constant test situation, the variability in IG1-BB and IG1-VB (i. e., the combination of the athlete's inherent variability and task variability due to the set constraints) probably exceeded the optimal amount of movement variability for this task. The transfer of variable practice to a constant situation did not occur accordingly, leading to no superior performance compared to the other groups. Therefore, variable training seems to be less adequate for "constant" situations. Nevertheless, our analyses unveil rather opposite results compared to other differential learning studies, which all report better performance even in constant test situations (e. g., Schöllhorn et al., 2006).

Although variations that do not typically occur in the game were purposely set (such as deliberately missing the basket by shooting at the right rim, that is, participants were also purposely asked to execute errors), players could not enhance their performance to that effect. As for the basketball experiment, no intervention group showed increase in performance; therefore, it can be concluded that the level remained the same (i. e., there were no negative interferences due to the applied perturbations).

Concerning the variations used in this study, it could be assumed that the differences were not appropriate for such a goal (i. e., the free throw) and that with respect to this goal the exercises were no longer interacting with each other. As research on the contextual interference effect (Brady, 2004) or differential learning (Birklbauer et al., 2006; Frank et al., 2008) demonstrated the existence of an optimal amount of variability. It appears that the solution space, which includes the diverse executions, spans over a different area of (execution) variability for constant tasks in comparison to variable tasks. Therefore, with respect to movement, the solution space must then be adequately chosen (Birklbauer et al., 2006).

This optimal amount of variability not only depends on various moderator variables (e. g. training age, skill level, experience, physical condition) (Haudum et al., 2009; Schöllhorn et al., 2009 a), but also on the available time (i. e. whether one analyses the short or long term effect of practice). For our intervention studies, the time was perhaps too short to benefit from the induced variations. If time is limited, the natural variability within a shot or strike in the "constant" situation might be enough for a performance increase. The disadvantage is that if there is a change in technique, equipment or other constraints constant practice will not allow for appropriate adaptation due to the constant training situation. However in the long run, larger differences that decrease over the progress of training will later allow finer variations (Schöllhorn et al., 2009 a), which then may result in an establishment of superior performance.

So, for the constant situation in the volleyball experiment (wherein natural task variability was higher than in the basketball experiment's free throw situation), the "normal" variability in the IG2-VB seemed to be equally effective in this period of time as IG1-VB, as both increased their performance, but none could outperform the other intervention group. However, it cannot be concluded that variable training is not efficient in constant situations in the long run. Studies to investigate the effect of variable practice in constant situations over a longer period of time are needed to give solid advice.

An apparent aspect, especially in the free throw experiment, is the number of shots performed during the intervention. Since participants had a certain training age and assuming that the participants had already practiced hundreds of free throws prior to the intervention (and perhaps have established their individual routine prior to the shots), the intervention-induced variability could not be successfully transferred to the free throw in this short period of time. Since the process to become an expert needs thousands of shots (Baker et al., 2003), the additional practice time in form of this intervention might have been too short to reflect an increase in free throw performance on such level of play. This underpins that performance enhancement at a certain skill level, especially for "constant" skills, takes time and enhances number of shots.

CONCLUSION AND PERSPECTIVES

In conclusion, the intervention-induced variability leads to benefits in variable situations, whereas for rather constant situations (i. e. basketball free throw), it seems to require a different amount of induced variability. For the free throw, performance was similar for both intervention groups; however, for the variable transfer task situation (i. e. jump shots) a positive tendency occurred in form of an outside transfer of the variable training situation.

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DIFERENCIJUOTO MOKYMO POVEIKIS JUDĖJIMO ĮGŪDŽIAMS LAVINTI

Anita Haudum, Jürgen Birklbauer, Kröll Josef, Erich Müller
Zalcburgo universitetas, Zalcburgas, Austrija
Christian Doppler laboratorija „Slidinėjimo biomechanika“, Zalcburgas, Austrija

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Ir sportininkas, ir treneris turi tą patį tikslą – pagerinti sportinį parengtumą.

Tikslas: nustatyti, kaip diferencijuotas mokymas veikia baudų metimų (žaidžiant krepšinį) ir kamuolio atmušimo (žaidžiant tinklinį) rezultatyvumą.

Metodai. Tiriant krepšininkus (prieš eksperimentą, po jo ir po judesio įgūdžio išlaikymo) buvo registruojami baudos metimai (sėkmingų metimų skaičius). Norint nustatyti judesio įgūdžio pritaikymą žaidžiant krepšinį buvo registruojami metimai pašokant. Tiriant tinklininkus kamuolio atmušimo kaitumas buvo didinamas apribojant rankos judesį (naudotas elastinis pasipriešinimas). Antroji intervencinė ir kvazikontrolinė grupės treniravosi įprastomis treniruotės sąlygomis. Kamuolio greitis ir metimų tikslumas buvo analizuojami taikant pastovumo ir kaitumo testus.

Rezultatai. Jokių reikšmingų skirtumų neaptikta tiriant baudos metimus (p > 0,05) ir įgūdžių perkėlimo situacijas (p > 0,05). Tačiau kaitumo grupėje buvo pastebėta teigiama tendencija įgūdžių perkėlimo pratybose. Diferencijuotas mokymas pagerino tinklininkų kamuolio atmušimų greitumą atliekant kaitumo testą (p < 0,05), tačiau atliekant pastovumo testą (p < 0,05) ir tiriant metimų tikslumą (p < 0,05) panašių rezultatų negauta.

Aptarimas ir išvados. Abiem eksperimentais nustatyta judesių lavinimo, taikant kaitos principus, reikšmė, ypač svarbi pritaikant judesių įgūdžius kintamomis sąlygomis. Visgi, ypač pastovumo situacijose, reikia atsižvelgti į tokius tarpinius kintamuosius kaip amžių ir kitų sporto šakų kultivavimą, dalyvavimą fizinėje veikloje norint pritaikyti tinkamą išorinį ar intervencinį kaitumą.

Raktažodžiai: diferencijuotas mokymas, kaitumas, prisitaikomumas, žaidimai su kamuoliu.

Corresponding author **Haudum Anita**
Department of Sport Science and Kinesiology, University of Salzburg
Christian Doppler Laboratory "Biomechanics in Skiing"
Rifer Schlossallee 49
5400 Hallein-Rif
Austria
Tel +43 650 50 60 41 8; +43 662 80 44 48 82
E-mail anita.haudum@sbg.ac.at

PHYSICAL EDUCATION TEACHERS' PERCEPTIONS OF SCHOOL HEALTH EDUCATION AND SOCIAL SUPPORT FOR IT: RESULTS OF THE PILOT STUDY

Rasa Jankauskienė, Brigita Miežienė
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Health education (HE) is integrated in various modules especially in biology and physical education (PE). Therefore the quality and effectiveness of integrated health education should be analyzed systematically.

Research aim. The aim of the study was to examine PE teachers' perception of health education and social support for HE at their schools.

Research methods. The data of convenience sample consisting of 70 physical education teachers (62% were women) from one of the largest Lithuanian cities were analyzed. Respondents ranged in age from 25 to 69 years, average age was 45 ± 11 years. 44.8 percent of participants indicated that they work at school which belongs to the SHE (School for Health in Europe) network. Anonymous questionnaire was developed to assess PE teachers' health education perceptions and attitudes towards HE.

Research results. Only one of ten physical education teachers understood conception of HE and correctly defined its main goal. Neither teachers from schools within the SHE network, nor the ones who began their career after Independence fundamentally differed in their understanding and attitudes towards HE from teachers who did not belong to the SHE network or began their carrier before Independence. The findings of the current study demonstrated that in this sample PE teachers' behavior change – related competencies were not well-developed for the implementation of effective and safe HE.

Discussion and conclusions. This pilot study showed that HE perception of PE teachers' was incorrect and their attitude towards health education should be optimized. No important differences were observed between HE perceptions of teachers in regard of school belonging to SHE network. PE teachers working in SHE school network reported higher social support for HE activities.

Keywords: health education, physical education, instrumental competencies.

INTRODUCTION

Since Lithuania became an integral part of Europe as well as the world community, human life is more and more affected by trends common for many developed countries: global integration, technological changes and sedentary lifestyle. In recent decades, growing culture of consumerism has aggressively unfolded in cultural and social fields, changing personal value system, touching the human self-awareness and interpersonal relationships. Mass culture and consumption are phenomena of economic growth in democratic countries, but in a young

democracy development of consumerism takes particularly aggressive and often distorted forms. Social, cultural and even political ill-preparation of a country to accept the opened-up possibilities of freedom evoke devastating consequences for its citizens, touching not only personal and interpersonal relations, but also one the most expensive human assets – their health. Some of the most sensitive parts of our society are children and adolescents.

Health-related behaviour of school-aged children in Lithuania is problematic. The number of schoolchildren who smoke tobacco and consume alcohol is higher than in other EU countries

Schools are considered to be settings for both health education and health promotion. Complementary to the national initiatives, health promoting school is a part of a global strategy for health promotion development (Jourdan et al., 2008). Health education (HE) is any combination of planned learning experiences based on sound theories that provide individuals, groups, and communities the opportunity to acquire information and skills needed making quality health decisions (*Joint Committee on Terminology*, 2001). HE is purposely created situation in order to provide knowledge, to form positive health-related behaviours and attitudes as well as healthy living skills, induce bad habits refusal and change personal behaviour for better health. HE is the basis for health promotion (Cottrell et al., 2005). Research shows that schoolchildren brush their teeth, eat healthier more often, they are less bullied and have fewer bad habits at schools where health promotion programs were implicated and received greater attention in comparison to those where those activities were developing slowly (Zaborskis et al., 2005). Thus, successfully organized health education activities at schools can significantly reduce the prevalence of harmful habits and improve health status of schoolchildren.

HE is not compulsory in Lithuanian schools. Rather, education is based on the idea that HE should be integrated into other subjects and primarily into are biology and physical education. Therefore the quality and effectiveness of integrated health education should be analyzed systematically.

Outstanding theories of behaviour change (i. e. *The Theory of Reasoned Action and the Theory of Planned Behaviour)* assume that individuals consider behavioural consequences before the particular behaviour, and the incidence of actual behaviour performance is proportional to the amount of control an individual possesses over the behaviour and the strength of the individual's intention in performing the behaviour (Sheppard et al., 1988; Ajzen,Manstead, 2007). Unfortunately, understanding of behavioural change techniques in our schools is complicated because of the lack of evidence – based knowledge and conviction that information giving or teacher – centred approach is the proper way to teach HE. However, the transference of knowledge and development of appropriate attitudes are not enough, formation of certain skills and competencies is necessary (Jociutė et al., 2008). Consequently, the analysis of behavioural change – related competences of PE teachers is the question worth consideration.

Competence in educational area is understood as completeness of knowledge, skills, attitudes, values and personal characteristics (Jucevičienė, Lepaitė, 2000). This means that the teacher of physical education should have not only enough knowledge and skills to teach various health topics, but also good understanding of the subtleties of teaching methods (Jociutė et al., 2008). PE teachers', who are supposed to be HE providers, perception of HE and their competencies regarding behaviour change is an understudied area. So, research in the field of physical education teachers' knowledge about health education, their preparation to carry out health promotion activities is very important. The aim of the study was to examine PE teachers' perception of health education and social support for HE at their schools.

We hypothesized that: 1) PE teachers, who started their carrier after the Independence of Lithuania would have more proper perception of HE; 2) PE teachers working within the SHE network would have more proper perception of HE and more positive perception of social support than those working outside the SHE network.

RESEARCH METHODS

Participants. Convenient sample of PE teachers from gymnasiums and secondary schools of one of the biggest Lithuanian cities was formed. The study involved a total of 73 PE teachers, 62% were women. Nobody refused to participate in the study, but three questionnaires were damaged, so the final sample consisted of 70 subjects. Respondents ranged in age from 25 to 69 years, an average age was 45 ± 11 years. 95.7% of participants had

higher education qualifications. Respondents' work experience lasted from 1 to 48 years, an average of their work experience was 20.2 ± 12.5 years; 62.9% of teachers reported that their teaching experience was less than 20 years (64% of them were women); and 37.1% of teachers reported that their professional career lasted 20 years or more (65 percent were women). 44.8% of participants (58% of them were women) indicated that they worked at school, which belonged to the SHE network.

Measures. The questionnaire was developed specially for this study. Participants were asked to report demographic data, further they were asked whether they integrated health education activities in physical education lessons (Yes / No); if they did, how they understood HE (open ended question); if they applied student – centered teaching methods of HE (Yes / No) and if they did, what methods in particular they used (open ended question); if the school community actively supported health promotion activities (Yes / No); and finally, the areas in which teachers had the least knowledge were determined (list of areas).

Procedure. The study was conducted in accordance with the principles of benevolence and anonymity. Those, who did not want to participate in the study, could refuse. Teachers were visited at their schools by the research team. Questionnaires were distributed and filled in in the free time from their classes. There also was the opportunity to fill them in at home. The questionnaire included 20 questions; it took approximately 15 minutes to fill in.

Statistical analysis. Analysis was conducted using statistical package *SPSS for Windows 17.0*. The differences between the groups were evaluated on the basis of χ^2 test and the results of the differences were considered statistically significant if the error probability value p was less than 0.05.

RESEARCH RESULTS

First, we tried to find out PE teachers' competencies in HE. Surprisingly, only 7.1 percent of participants correctly answered the open question about the main objective of HE, the distribution of the correct answers between respondents within and, outside the SHE network was similar accordingly: 6.5 and 7.7 ($\chi^2 = 2.09$; df = 1; p = 0.35). All respondents (n = 70) indicated that HE was integrated in their PE lessons. However, only 7.1 percent of participants presented the right definition of HE. It is worth noting that all of them were working in schools which did not belong to the SHE network, accordingly 12.8 and 0% ($\chi^2 = 9.74$; df = 1; p = 0.01). It is interesting to note that 51.4 percent of teachers used active teaching methods during PE classes. Answers distributed between working within and outside the SHE network teachers in a similar way 948.8 and 48.7). However, only 31.4 percent of teachers listed one or more active student – centered teaching methods which were used in their classes. Teachers who worked within and outside the SHE network did not differ in their answers according to the application of student – centered teaching methods accordingly: 6.5 and 23.1% ($\chi^2 = 3.68$; df = 1; p = 0.16).

Further, we tried to determine whether work experience was related to perceptions and attitudes towards HE. We compared these variables between PE teachers who began their career before and those who began it after the Independence. The perception of HE did not differ in the groups of teachers with different length of carrier, both who started their carriers before and after the Independence were similarly wrong in their answers accordingly: 6.8 and 7.7% ($\chi^2 = 0.02$, df = 1, p = 0.89). However, the question about the main goal of HE was correctly answered more often by younger teachers accordingly: 11.4 and 6% ($\chi^2 = 3.60$, df = 2, p = 0.17). Unexpectedly, more teachers with teaching experience of more than 20 years reported that they applied several student – centered methods compared to those with less experience accordingly: 30.8 and 6.8% ($\chi^2 = 9.74$; df = 1; p = 0.01).

Then we tried to identify the areas where the lack of knowledge and teaching skills was the greatest. All PE teachers (100 percent), regardless of schools they worked at- within or outside the SHE network, emphasized three main areas – prevention of harmful habits, healthy diet and communication as well as collaboration. However, only 8.6% of teachers admitted that they lacked knowledge and skills in teaching about sexuality, mental health (20%), accident prevention (4.3%), disease prevention (4.3%), personal hygiene (7.1%), allergies (22.1%) and stress reduction (21.4%).

Finally, support of social environment for HE at schools was explored. As many as 58.6 percent of PE teachers reported that there were not enough PE – related HE events organized in their schools.

As it was expected, this statement was supported by teachers who worked in schools outside the SHE network 71.8 and 41.9% (χ^2 = 6.35; df = 1; p = 0.01). Even 67.1 percent of teachers agreed with the statement that the school community did not participate in HE activities. This statement was also more frequently supported by teachers outside the SHE network, 79.5 and 51.6% (χ^2 = 6.08; df = 1; p = 0.01). Every other teacher reported that promotion of health education in their school was accomplished under the project work. 8.6% of PE teachers reported that there was no HE in their schools. Teachers who worked in schools outside the SHE network agreed with it more often than those who worked within the network, 15.4 and 0% (χ^2 = 5.22; df = 1; p = 0.02). As many as 55.7% of teachers indicated that the optimization of HE at schools was influenced by the lack of funding, 15.7% reported the lack of competent professionals, and 18,6 percent reported that there was not enough attention from school administration. One third of respondents agreed with the statement that there was a lack of school community support for HE. The lack of school community support was more often indicated by PE teachers who did not work within the SHE network than by those who worked in it, 43.6 and 22.6% respectively, 79.5 and 51.6% (χ^2 = 3.38; df = 1; p = 0.07).

DISCUSSION

This pilot study was aimed at examining physical education teachers' perceptions of health education and comparing those variables between physical education teachers working in SHE schools and schools outside the SHE network. Moreover, we expected that teachers who started their carriers after the Independence of Lithuania would have more positive evaluations of investigated variables than those who started working before the Independence. The results of the study showed that physical education teachers' perceptions of health education were unsatisfactory because the majority of teachers could not explain the main aim and did not understand the essence of health education. This study was pilot and the interpretation of its results should be very limited having in mind small convenience sample. However, our findings are important for further studies which should test our results in representative randomized samples. Moreover, further studies might be directed to compare instrumental behavior change – related

competencies of physical education teachers among samples of postsoviet countries, where integrated health education in schools and gymnasiums is a substitute of the compulsory subject and some western countries, where HE is a compulsory subject.

Our results indicated that perception of health education did not differ in the groups of teachers with different length of carrier, but unexpectedly, more teachers with teaching experience of more than 20 years admitted using methods for active health promotion more often than teachers with less experience. These results are not in consistence with D. Castelli and L. V. Williams (2007) who found that years of experience were not associated with confidence in health education, but age was – the older the teacher, the lower the confidence. However, interpretation of our results is limited because of small convenience sample and this finding might be incidental.

We expected that physical education teachers working within the "Schools for Health in Europe" (SHE) network would understand and implement the goals of health education more frequently than teachers outside the SHE network. The survey revealed that only one out of ten physical education teachers understood the concept of health education and correctly defined its main goal. Though half of teachers said they used active teaching methods during physical education classes, only one third of them could list one or more of these methods. Unfortunately, working within the SHE network was not associated with better results. The study in China province showed that after changes from teacher – centred teaching methods to active student – centred methods, school community gained knowledge and skills and developed a deeper understanding about health. Health impact was also demonstrated in reduced injuries, smoking and educational impact was demonstrated in improved relationships of children with parents and teachers, improved social qualities and teacher satisfaction (Aldinger et al., 2008). As far as it relates to physical education teaching methods, for example, in Denmark traditional physical education with the focus on making experiences in the classroom, on the sports ground or in the gym was replaced by a pilot project employing dialogue groups as a didactic method in physical education, reflecting experiences as a part of the learning process in those arenas. This case study showed that retelling, rethinking, deconstructing,

joking about bodily experiences in sport and physical activity were educative experiences – if an adequate pedagogical method was employed (Christensen, 2007). Moreover, S. G. Trost (2004) also suggests that teachers should care about schoolchildren's knowledge, attitudes and health-related competencies, rather than physical fitness only. Links of physical education and public health are beyond doubt. However, if physical education is narrowed to physical fitness testing, movement skill development and competitiveness, its role in public health is diminished and it lacks attractiveness (Trost, 2004). Therefore, student – centred teaching approach should dominate in health education and physical educators should be trained to use these methods despite the fact that health education is not compulsory, but integrated into physical education subject.

Physical education teachers in this sample, regardless of the school they worked in, within or outside the SHE network, showed lack of knowledge and skills in the prevention of harmful habits, healthy eating and communication areas. It is tempting to draw more attention to the latter area. First, promoting health, educator (teacher of physical education) must be able to communicate and promote co-operation (Trost, 2004; veikauskas, 2005), therefore the lack of these skills confirms physical education teachers' difficulties to perform the work related to health education and health-related physical activity. However, only less than ten percent of teachers in the current study admitted that they lacked knowledge and skills in teaching about sexuality, accident prevention, disease prevention, and personal hygiene. Some other studies revealed that teachers' understanding of certain areas of expertise might differ from the actual content of the knowledge and skills and teachers have the tendency to overestimate their abilities. For example, in the study of D. Castelli and L. Williams (2007) results indicated that physical education teachers were very confident in their knowledge of health-related fitness, however their actual health-related fitness test did not meet the expected. Moreover, it was found in Australia that physical education teachers in their diet recommendations for overweight adolescents provided scientifically unjustified and harmful weight-loss techniques (O'Dea, Abraham, 2001). Moreover, in their review article, J. Evans et al., (2004) suggested that prominence of overweight and obesity, inaccurate interpretation of facts

and even scientific speculations contribute to the development of harmful attitudes towards health which are transmitted by physical education teachers. Therefore, our analysis leads to the idea that it is necessary not just to reveal the subjective opinions of physical education teachers about their health education competencies, but also to investigate them objectively.

Moreover, teachers should be highly critical consumers of the scientific information related to young people, physical activity and public health. First of all, health education should be safe (O'Dea, 2005). Preparing teachers of physical education, basic health behavior change theories should be presented as well as active teaching methods, so that physical education teachers would know and have the skills for effective integration of behavior modification methods in the physical education program. These methods help convert health-related information to knowledge, as well as personally meaningful issues affecting each person's behavior in expected ways (Tones, 1986; Mačiūnas et al., 2006). Therefore, the findings of the current study demonstrated that physical education teachers' behavior change – related competencies were not well-adapted for the implementation of integrated health education. It can be concluded that professional growth is very important and lifelong learning is essential having in mind that after Lithuanian Independence the aim of the physical education had changed from competitive sport to health – related physical activity promotion.

Finally, more than two thirds of teachers in our study agreed that school community did not participate in health promotion activities. As it was expected, teachers who worked at schools were health promotion was implemented under the SHE network reported that health education was being implemented, there was a sufficient number of health promotion events organized in their schools and the school community participated in health promotion activities more often than teachers outside the SHE network. This result is not surprising because of the main aims of the SHE network. However, this pilot study added evidence that schools in SHE network provided better social environment for health promotion compared to those schools outside the network.

The main weakness of the present study is small and convenience sample, therefore the interpretation of the results should be very limited. Nevertheless, the authors do believe that the

problem exists and further nationally representative randomized studies should be carried out to assess behavior change – related competencies of physical education teachers.

CONCLUSIONS AND PERSPECTIVES

The results of the pilot study revealed that health education perceptions of physical education teachers were incorrect and they should be optimized. PE teachers working in SHE schools network reported higher levels of social support for HE activities.

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KŪNO KULTŪROS MOKYTOJŲ SAMPRATA APIE SVEIKATOS UGDYMĄ MOKYKLOJE

Rasa Jankauskienė, Brigita Miežienė
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Lietuvoje moksleivių su sveikata susijęs elgesys yra problemiškas. Ypatingas dėmesys sveikatos ugdymui ir stiprinimui turėtų būti skiriamas šalies mokyklose. Todėl kūno kultūros mokytojų elgesio keitimo kompetencijų ir požiūrio į sveikatos ugdymą kūno kultūros srityje tyrimai labai aktualūs.

Tikslas: nustatyti sveikatos ugdymo suvokimą ir ištirti, kaip bendrojo lavinimo mokyklų kūno kultūros mokytojai suvokia socialinę paramą sveikatos ugdymui.

Metodai. Iš viso buvo tiriama 70 kūno kultūros mokytojų, iš kurių 62% sudarė moterys, 44,8% tiriamųjų nurodė, kad dirba mokykloje, kuri priklauso „Mokyklos – europiečių sveikatai" (MES) tinklui. Tyrimo metu buvo naudojama specialiai šiam tyrimui sudaryta anketa, kurią sudarė demografiniai klausimai ir klausimai apie sveikatos ugdymą.

Rezultatai. Tik vienas iš dešimties kūno kultūros mokytojų supranta, kas yra sveikatos ugdymas ir teisingai nurodo pagrindinį jo tikslą. Nei mokyklos priklausymas MES tinklui, nei profesinės karjeros pradžia po Nepriklausomybės neturėjo esminės reikšmės sveikatos ugdymo suvokimui ir požiūriui į jį. Daugiau kaip du trečdaliai mokytojų sutiko su teiginiu, kad mokyklos bendruomenė nedalyvauja sveikatos stiprinimo veikloje, tačiau dažniau su tuo sutiko MES tinklui nepriklausančių mokyklų mokytojai.

Aptarimas ir išvados. Šios imties kūno kultūros mokytojų sveikatos ugdymo suvokimas yra optimizuotinas. Nenustatyta esminių sveikatos ugdymo suvokimo ar požiūrio į jį skirtumų, lyginant MES tinklui priklausančių ir nepriklausančių mokyklų kūno kultūros mokytojus. MES tinklui priklausančių mokyklų mokytojų suvokiamas socialinės aplinkos palankumas sveikatos ugdymo veiklai yra geresnis negu šiam tinklui nepriklausančių mokyklų mokytojų.

Raktažodžiai: sveikatos ugdymas, kūno kultūra, instrumentinės kompetencijos.

Corresponding author **Rasa Jankauskienė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 37 302638
E-mail r.jankauskiene@lkka.lt

THE RELATIONSHIP BETWEEN BODY IMAGE AND EXERCISE ADHERENCE IN FITNESS CENTRE EXERCISING SAMPLE

Rasa Jankauskienė, Brigita Miežienė
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. The analysis of factors which might influence exercise adherence is important issue for physical activity promotion. Studies show that exercisers' body image is important factor associated with well being, exercise motivation and specific exercise–related behaviour.

Research aim was is to examine the relationship between exercise adherence, body image and social physique anxiety in a sample of fitness centre participants.

Research methods. Members of fitness centres (n = 217, 66 of them were women) provided their answers on exercise experience, in three subscales (appearance evaluation, appearance orientation and overweight preoccupation) of *The Multidimensional Body-Self Relations Questionnaire* (MBSRQ-AS; Brown et al., 1990) and *Social Physique Anxiety Scale* (SPAS; Hart et al., 1989). Mean age of the sample was 29.02 (9.85) years (range = 18–68 years).

Research results. Women demonstrated higher appearance orientation, overweight preoccupation and social physique anxiety compared to men. However, we observed no significant differences in appearance evaluation, appearance orientation and overweight preoccupation in the groups of different exercise experience of men and women. When overweight respondents ($\geq$ 25 kg / m²) were excluded from the analysis, there were no statistically significant differences observed in body image and social physique anxiety in exercise experience groups of men and women. Exercising longer than 6 years significantly predicted overweight preoccupation [95% CI: 1.25–16.94] controlled by age and gender.

Discussion and conclusions. Exercising men demonstrated more positive body image and lower social physique anxiety compared to women, except for appearance evaluation. There were observed no body image and social physique relationships with exercise adherence observed in the sample of fitness centre participants, however, exercise experience longer than 6 years predicted overweight preoccupation.

Keywords: body image concerns, exercise experience, self-presentation.

INTRODUCTION

The analysis of factors which might influence exercise adherence is important issue for physical activity promotion. Studies show that exercisers' body image is important factor associated with well being, exercise motivation and specific exercise–related behaviour (Melbye et al., 2008). Cross-sectional studies show that exercise–engaged individuals are more satisfied with their physical appearance than non-exercisers (Hausenblas, Fallon, 2006). However, intervention studies show that fitness workouts may increase women's drive for thinness

(Zabinski et al., 2001). There is much evidence that body image concerns interfered with women's enjoyment when participating in an aerobics class (Frederick, Shaw, 1995). However, body image concerns might motivate men and women to start exercising and assumption exists that a certain level of body image dissatisfaction motivates for the healthy lifestyle (Heinberg et al., 2001). Yet, it seems that body image depends on exercise motivation: individuals who get involved in exercising due to appearance improvement are less satisfied with their appearance (Strelan, Hargreaves, 2005).

Social physique anxiety (SPA) is the anxiety a person experiences as a result of the potential of their body being negatively evaluated by others (Hart et al., 1989). Studies show that women have significantly higher SPA scores than men (Lanning et al., 2004). There is evidence that exercisers' SPA decreases with age (Thogersen-Ntoumani, Ntoumanis, 2006). Moreover, SPA is associated with appearance – related exercise motivation (Sabiston et al., 2005), weight and muscle – related body comparison (McCreary, Saucer, 2009), body and weight dissatisfaction (Crawford, Eklund, 1994), and disordered eating (Haase, Prapavesis, 1998).

The relationships between SPA and physical activity are not well understood. Study of R. G. Bowden et al. (2005) showed that students enrolled in a fitness course had higher SPA scores as compared to those involved in emergency care course. However, there is evidence that self-presentation concerns provide a major motivation to exercise (Kowalski et al., 2001). The relationships between SPA and exercise adherence are unclear. There is some evidence that higher commitment to exercise is related to lower level of SPA among women (Finkenberg et al., 1998), however there is no evidence about men. Moreover, it remains unclear how exercisers' body image and SPA are related to exercise adherence. In our study we expected that: 1) exercising men would demonstrate more positive body image and lower SPA compared to women; 2) exercise experience would be related to positive body image and SPA changes among fitness centre exercising men and women. **The aim of the present study** was to examine the relationships between exercise adherence, body image and social physique anxiety in a sample of fitness centre participants.

RESEARCH METHODS

Participants and Procedure. The consent was obtained from the administration of private Kaunas fitness clubs to carry out the survey. The survey was done agreeably to good will, as well as ethical and legal principals. The questionnaires were filled in anonymously. The procedure of completing questionnaires took place after fitness classes in the presence of one of the investigators, and after the completion the questionnaires were collected. The participants were given as much time as they needed, although all of them completed the questionnaires in less than 20 minutes. All the participants were informed about the aim and anonymity of the research and instructed on how to complete the questionnaires. They were encouraged to respond honestly and independently. Incompletely or inaccurately filled questionnaires were excluded (n = 34), thus the whole sample used for this study consisted of 217 respondents (66 of them were women). The mean age (SD) of the sample was 29.02 (9.85) years (range = 18–68 years). Mann-Whitney U test showed that women were significantly older compared to men, accordingly: 32.29 (10.34) and 27.59 (9.31), p < 0.001.

Instruments. Exercise experience was assessed by question: "How many years have you been engaged in fitness activities (not only in this fitness centre)?" with items: "Less than one year; one–two years; three–four years; five–six years; more than six years".

The short version of *Multidimensional Body-Self Relations Questionnaire* (MBSRQ-AS) (Brown et al., 1990) was used to assess the participants' body image (body areas satisfaction scale was not included in this study). MBSRQ-AS is a 34- item self-report inventory for the assessment of self-attitudinal aspects of the body-image construct. Body image is conceived as one's attitudinal dispositions toward the physical self (Cash, 2004). *Appearance evaluation* represents the feelings of physical attractiveness or unattractiveness, satisfaction or dissatisfaction with one's looks. It has been found that high scorers feel mostly positive and satisfied with their appearance. *Appearance orientation* reflects feelings of being fit or unfit. High scorers place more importance on how they look, pay more attention to their appearance, and get engaged in extensive grooming behaviors. *Overweight preoccupation* subscale assesses a construct

reflecting fat anxiety, weight vigilance, dieting, and eating restraint. Self-classified weight scale reflects how one perceives and labels one's weight from extreme underweight to overweight.

A Lithuanian translation of the MBSRQ-AS was developed using double back-translation. Factor structure of the MBSRQ-AS was examined by Exploratory factor analysis (EFA) using principal axis factoring with *Varimax* rotation. Based on the pattern matrix, items with the load less than 0.40 were identified and eliminated. The six-factor model appeared to be the best fit to the data. KMO coefficient was 0.82, Bartlett's test of sphericity – $p < 0.001$. Six factors together explained 61.28% of variance. The six extracted factors were with Eigenvalues greater than 1 (5.14; 4.57; 2.10; 1.38; 1.09; 1.05). As hypothesized, the first factor (appearance evaluation) consisted of 7 items. The second factor (appearance orientation) consisted of 6 items. The third factor (overweight preoccupation) consisted of 4 expected items. Other items from appearance orientation scale formed the fourth (3 items) and fifth (3 items) factors. The sixth factor (self-classified weight) consisted of 2 expected factors. In this study only the first three factors (appearance evaluation, appearance orientation and overweight preoccupation) were analyzed. Appearance evaluation, appearance orientation and overweight preoccupation subscales had acceptable internal consistency, respectively: ($\alpha = 0.86$; 0.75; 0.79).

The double-translated Lithuanian version of Social Physique Anxiety Scale (SPAS; Hart et al., 1989) was used to assess self-presentation concerns. The scale consisted of 12 items and measured the degree of anxiety people experienced when they perceived their physique to be evaluated by other people. Example items from the scale included: "I am comfortable with how fit my body appears to others"; and "Unattractive features of my physique or figure make me nervous in certain social settings". Respondents rated each item on the Likert scale ranging from 1 (*Not at all*) to 5 (*Extremely true*). EFA using principal axis factoring with *Varimax* rotation showed that two factor model appeared to be the best fit to the data. KMO coefficient was 0.84, Bartlett's test of sphericity – $p < 0.001$. Two factors together explained 81.1% of variance. Eigenvalues of the factors were (4.47; 2.45). The first factor consisted of 7 items (No.: 3, 4, 6, 7, 9, 10, 12), the second factor consisted of 5 items (No.: 1, 2, 5, 8, 11). The first factor was directly related to social

physique anxiety, the items in the second factor were conversely directed. The first factor had good internal consistency in this sample, Cronbach's $\alpha = 0.90$, and was used in further analysis as social physique anxiety variable.

The Body Mass Index (BMI) was calculated from self reported weight and height measures (weight (kg)/height (m) ²). The respondents were divided into three groups (≤ 18.49 kg / m²; 18.5–24.99 kg / m², and ≥ 25 kg / m²). The participants were asked to assess their body weight comparing it to the known height-weight standards (the choices given were: *too thin*, *normal*, *too heavy*).

Data Analysis. Statistical analysis of the data was carried out by using the software package *SPSS 13.0 for Windows*. Statistical association between qualitative variables was estimated by using chi square value. Mann-Whitney test was used to assess the mean differences between groups. The results were regarded statistically significant if the p-value was equal or less than 0.05. Binary logistic regressions were used to predict a categorical (dichotomous) variable from a set of predictor variables.

RESEARCH RESULTS

As many as 19% of the respondents were members of fitness centres less than 1 year, 13,8% of respondents – 1–2 years, 22,4% – 3–4 years, 10,3% – 5–6 years and 34,5% – more than 6 years. 64 persons (29.5%) of the sample was overweight and 21 (9.7%) of the respondents were obese. There were no age differences observed in exercise adherence groups ($\chi^2 = 1.53$; df = 4; p = 0.82). Mann-Whitney U test showed significant age difference between the group of exercise involvement for 6 years and more and other participants, accordingly: 35.44 (10.48) and 25.76 (7.72), p = 0.0001.

There were significantly more overweight and obese men compared to women, respectively: 51% and 12.1%, $\chi^2 = 33.68$; df = 2; p < 0.001. Descriptive statistics for the age, body mass index (BMI), body image and SPA showed differences in the expected direction except for the appearance evaluation. Women were significantly older compared to men (32.29 (10.34) and 27.59 (9.31) respectively), Mann-Whitney U = 3560.5; p = 0,001). Men's BMI was higher, respectively 25.57 (3.80) and 21.93 (2.61), Mann Whitney U = 1981; p=0.001. Women scored higher in

appearance orientation (4.03 (0.59) and 3.39 (0.59)), Mann Whitney U = 2215.5; p = 0.001), overweight preoccupation (2.84 (1.00) and 2.19 (0.80)), Mann-Whitney U = 2913; p = 0.001), and SPA (2.29 (1.08) and 1.65 (0.70)), Mann-Whitney U = 3096; p = 0.001). However, there were no differences in appearance evaluation in men and women, respectively: 3.56 (0.60) and 3.54 (0.74), Mann-Whitney U = 4435.5; p = 0.80.

Further we tested how body image and SPA were associated with exercise experience controlled by age and gender. We excluded overweight and obese respondents ($\geq$ 25 kg / m²) from further analysis. There were 85 respondents excluded from the analysis and the final sample consisted of 132 exercisers (58 of them were women). Still we observed significant BMI differences in exercise experience groups. Polynomial appearance evaluation, appearance orientation, overweight preoccupation and social physique anxiety variables were transformed to binary variables using median. Binary logistic regressions showed that age 95% CI [0.91–1.01], gender 95% CI [0.56–3.15], and exercise experience 1–2 years 95%CI [0.21–2.23], 3–4 years 95% CI [0.19–1.91], 5–6 years 95% CI [0.44–4.65] and > 6 years 95% CI [0.03–1.13] lacked significant power to predict appearance evaluation (models' χ^2 = 9.17 (6), p = 0.16). Further analysis showed that gender predicted 5.54 fold higher appearance orientation 95% CI [2.25–13.65], but age and exercise experience did not predict appearance orientation (models' χ^2 = 25.49 (6), p = 0.001). Model for overweight preoccupation showed that gender (OR = 4; 95% CI [1.68–9.50]) and exercise experience (> 6 years) (OR = 4.61; 95% CI [1.25–16.94]) were significant predictors of overweight preoccupation (models' χ^2 = 31.79 (6), p = 0.001). Gender (OR = 3; 95% CI [1.28–7.03]), but neither age nor exercise experience were main predictors of SPA in this sample.

DISCUSSION

The present study was aimed to examine the relationships between body image, social physique anxiety and exercise experience in fitness centre exercising sample. We expected that longer exercise involvement would be related to more positive body image and lower social physique anxiety in men and women. The present findings showed that there was no significant body image and social physique anxiety differences in exercise

experience groups. Longer exercising men demonstrated higher overweight preoccupation compared to exercising less than one year, but the finding might be explained by significantly higher age and BMI in the first mentioned group. Logistic regressions showed that there was no significant relationship between exercise experience, body image and social physique anxiety in this sample. The finding that longer exercise experience predicted overweight preoccupation should be tested in further studies. Other studies showed that fitness workouts might increase women's drive for thinness (Zabinski et al., 2001). Studies in men showed that they wanted to have mezomorphic body type (McCreary, Saucer, 2009), what means striving for muscular but not fat body. However, the finding that longer exercising predicts overweight preoccupation might be incidental and therefore should be tested in future studies. There is lack of studies testing associations between exercise experience, body image and social physique anxiety, thus the interpretation of the findings is very limited. Future studies should test previous findings in representative randomized samples of fitness centre exercisers.

We expected that exercising women would demonstrate more negative body image and social physique anxiety compared to men. Our results supported other findings which revealed that women had typically poorer body image and higher social physique anxiety (Brown et al., 1990; Haase et al., 2002). Exercising women demonstrated higher appearance orientation, overweight preoccupation and social physique anxiety despite the facts that they were older and significantly less overweight compared to men. It might be explained by higher appearance-based socio-cultural pressures that females living in western countries experience. The present study supported the findings of A. Mi kinytė and A. Bagdonas (2010) who also found poorer women' body image compared to men in the representative sample of Lithuanian students using MBSRQ-AS measure (Brown et al., 1990). The present study suggested that appearance evaluation did not differ in both gender groups. It supported other findings which showed no appearance evaluation differences in Lithuanian men and women (Miškinytė, Bagdonas, 2010).

The main weaknesses of the study are small convenient sample and cross-sectional design. Future studies should test the direction of the relationships between body image, social

physique anxiety and exercise adherence with the prospective study designs. However, the associations between exercise adherence, body image and social physique anxiety have not been clearly understood and therefore should become the focus in further exercise research.

CONCLUSIONS AND PERSPECTIVES

Exercising men demonstrated more positive body image and lower social physique anxiety compared to women except for appearance evaluation. We observed no body image and social physique relationship with exercise adherence in this sample of fitness centre participants, however, exercise experience longer than 6 years predicted overweight preoccupation. Future studies should test previous findings in representative randomized samples of fitness centre exercisers.

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SVEIKATINGUMO CENTRUOSE BESIMANKŠTINANČIŲ ASMENŲ KŪNO VAIZDO IR MANKŠTINIMOSI SĄSAJOS

Rasa Jankauskienė, Brigita Miežienė
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hopotezė. Veiksnių, kurie gali veikti nusiteikimą mankštintis, analizė yra svarbi fizinio aktyvumo skatinimo sritis. Tyrimai rodo, kad besimankštinančio asmens kūno įvaizdis susijęs su jo gera savijauta, motyvacija sportuoti ir aktyviu gyvenimo būdu.

Tikslas: nustatyti ryšius tarp kūno vaizdo, socialinio nerimo dėl kūno išvaizdos priėmimo bei mankštinimosi sveikatingumo centruose trukmės.

Metodai. Anketinės apklausos būdu buvo nustatytas laisvalaikiu sveikatingumo centruose besimankštinančių asmenų (n = 217, iš jų 66 moterys) mankštinimosi stažas, pasitenkinimas savo išvaizda. Dėmesys savo išvaizdai ir rūpestis dėl antsvorio buvo nustatyti *The Multidimensional Body-Self Relations Questionnaire* skale (MBSRQ-AS – Brown et al., 1990), nerimas dėl socialinio išvaizdos priėmimo – *Social Physique Anxiety Scale* skale (SPAS – Hart et al., 1989). Imties amžiaus vidurkis – 29,02 (±9,85) m.

Rezultatai. Moterys labiau rūpinasi savo išvaizda, antsvoriu ir daugiau sunerimusios dėl socialinio išvaizdos priėmimo, lyginant su besimankštinančiais vyrais. Nebuvo rasta kūno vaizdo ir nerimo dėl socialinio išvaizdos priėmimo skirtumų įvairaus mankštinimosi stažo vyrų ir moterų grupėse. Analizuojant tik normalios kūno masės tiriamųjų duomenis taip pat nenustatyta esminių kūno vaizdo ir nerimo dėl socialinio išvaizdos priėmimo skirtumų mankštinimosi stažo grupėse, nors aptikta, kad ilgesnis nei šešerių metų mankštinimosi stažas buvo susijęs su rūpesčiu dėl antsvorio.

Aptarimas ir išvados. Besimankštinantys vyrai pozityviau vertina savo kūno vaizdą ir patiria mažesnį nerimą dėl socialinio išvaizdos priėmimo nei moterys. Tiriant šią imtį reikšmingų ryšių tarp mankštinimosi stažo ir kūno vaizdo bei nerimo dėl socialinio išvaizdos priėmimo nenustatyta, tačiau ilgesnis nei šešerių metų mankštinimosi stažas buvo susijęs su rūpesčiu dėl antsvorio. Tolesniuose tyrimuose gautas išvadas reikėtų patikrinti tiriant reprezentatyvias sveikatingumo centruose sportuojančių asmenų imtis.

Raktažodžiai: rūpestis dėl savo išvaizdos, mankštinimosi stažas, savęs reprezentavimas.

Corresponding author **Rasa Jankauskienė**
Lithuanian Academy of Physical Education
Sporto str. 6, Kaunas LT-44221
Lithuania
Tel +370 650 92569; +370 37 302638
E-mail r.jankauskiene@lkka.lt

SPREAD OF KNOWLEDGE ON OLYMPISM IN SCHOOL APPLYING THE INTEGRATED PROGRAMME OF OLYMPIC EDUCATION

Daiva Majauskienė[1], Saulius Šukys[1], Aušra Lisinskienė[2]
Lithuanian academy of Physical Education[1], Kaunas, Lithuania
Primary School of Batniava[2], Kaunas District, Lithuania

ABSTRACT

Research background and hypothesis. The present study deals with the Integrated Programme of Olympic Education in school. We hypothesized that pupils in schools where this program was executed would have more knowledge on Olympism.

Research aim was to determine the possibilities of spreading the knowledge on Olympism in schools applying the programme of the Olympic education.

Research methods. The sample consisted of the representative group of 2335 adolescents aged between 13 and 18 years. The study employed an Olympic Questionnaire (*Olympic Questionnaire* – Telama et al., 2002) in order to establish in what way the school provided Olympism-related information and what knowledge related to Olympism and Olympic Games the pupils possessed.

Research results. It was established that the contents of the Olympic education was various: the pupils were acquainted with various historic facts about the Olympic Games, their participants, symbolism, traditions, Fair play; pupils performed practical tasks and various festivals were organized at schools. The survey showed that the knowledge of pupils from the schools executing the programme of the Olympic education about the first Modern and the last Olympic Games was better. More pupils from these schools knew the Paralympics Games.

Discussion and conclusions. The survey showed that teachers from schools where the integrated programme of the Olympic education was executed integrated information about Olympism into their teaching subjects. Knowledge about the Olympic Games and their participants among pupils in these schools were much better as well.

Keywords: Olympism, Integrated Olympic Education, Olympism-related knowledge.

INTRODUCTION

Issues of the Olympic movement, universality and significance of principles and values of Olympism in the modern world of sport have always been studied by philosophers and educators (McNamee, 2006; Parry, 2006; Reid, 2006; Torress, 2006; Corrall et al., 2010). Speaking about the universal values of Olympism, first of all their role for the education of children and young people is borne in mind. So, the necessity of passing from theory to practice is accentuated (Pope, 2007). The integrated programme of the Olympic Education for children and young people (Programme of Olympic Education) was developed for spreading ideas and values of Olympism among pupils. It should be emphasized that the Olympic education is not a separate subject with a certain number

of hours in the curriculum. Olympic education is based on the multidisciplinary content integration by joining separate elements into the whole, and children's physical, mental and spiritual powers obtain a universal nature (Gerulskienė, 2007).

The main form of the Olympic movement at school is physical education. However, I. Smalinskaitė (2003) suggests that according to this model, systematic functions of the Olympic movement can be compared to the function of physical education as of a subsystem in the structure of the system of general education. Other scientists analysing issues of the Olympic movement claim that both physical education teachers and teachers of other subjects should speak about the Olympic Games, Olympism and related issues as well as give examples on those issues (Parry, 2003; Binder, 2005; Pawlucki, 2006; Naul, 2008 a, 2008 b; Peneva, 2009). R. Mažeikienė (2004) added that the Olympic education should not be related only to physical education and extracurricular activities. Olympic education should be executed in art, drawing, technology, music lessons in primary schools and be included the humanities and social sciences in secondary schools. If pupils learn about the evolution of the Olympic movement, history of the Olympic Games, the most important ideas of the Olympic spirit in lessons of different subjects, they will better realize the significance of the Olympic ideas and the necessity of their implementation.

Thus, educators, parents, the parliament of pupils, and the total school community can contribute to the implementation and development of the integrated Olympic education by rendering Olympic ideals and nurturing moral values (Puišienė, 2000). In this aspect the Olympic education in general is essential with its goals for solving general issues of education of child's personality which requires much attention at school. As far as we know, much attention is also paid to the Olympic education at schools in other countries too, but there is lack of research providing data about the efficiency of the Olympic education in the development pupils' knowledge about Olympism and nurturing related values. Only pupils' knowledge about Olympism and the Olympic Games has been researched more (Puišienė, 2000; Telama et al., 2002; Bronilowski, 2006; Вацеба, Юхымук, 2007). Thus, the **aim** of this research was to determine possibilities of spreading the knowledge on Olympism in schools by applying the Integrated Programme of the Olympic

Education. With this aim we tried to answer the following research questions: first, in what way Olympism-related knowledge is rendered; second, what Olympism-related knowledge pupils already possess. Our hypothesis was that better Olympism-related knowledge would be more characteristic of those pupils who learn in schools executing the integrated programme of the Olympic education.

RESEARCH METHODS

Research participants. The sample included Lithuanian schools representing main schools, secondary schools and gymnasiums. We applied multistage sampling strategy, i. e. we elected a number of schools at random, and from each school we selected a number of classes at random. In total, 30 schools were randomly selected. The total sample consisted of 2335 (1095 males and 1240 females) young adolescents between the ages of 13 and 18 years. Males and females were equally represented across the age groups. Some pupils (n = 1186) from the schools participated in the programme of the Olympic education and others (n = 1149) did not participate in this programme.

Methods. The method applied in the research was a questionnaire survey. We used the *Olympic Questionnaire* (Olympic Questionnaire – Telama et al., 2002) which had been applied when surveying pupils from different European countries. There were some open and some closed questions. In order to ascertain in what way the school provided Olympism-related information, the pupils were asked to indicate if they were explained about it in their schools, in which lessons and what type of information was rendered to them. They were asked if their schools organized any events related with the Olympic movement and what happened during these events. The pupils were also asked if they participated in any national events related to the Olympic movement. While ascertaining the pupils' knowledge related to the history of the Olympic Games, they were asked in which city the first Modern Olympic Games took place. Accordingly, they were asked where the last winter and summer Olympic Games took place. The pupils were also asked if they knew what the Paralympics Games were. They had to indicate Olympic champions and prize winners they knew and comment why those sportspeople were special for them.

As the questionnaire applied in the survey had already been used when surveying pupils of

different ages from other countries, we did not assess its validity and reliability and concentrated our attention on the accuracy of its translation by using help of two English specialists (the original questionnaire was in English) and clearness of the questions to the pupils which was checked by surveying 103 pupils from the 7–9th grades.

Procedures. The study was carried out during the lessons upon written consent by the Lithuanian Olympic Academy, Education Departments of different Lithuanian cities, and with prior agreement with school directors and teachers. It was carried out by the researchers themselves. Participation of pupils was based on the principles of anonymity and goodwill. Pupils were given as much time as they needed. Completed questionnaires were collected at once.

Statistical analysis. The data were processed applying SPSS 13.0 for Windows. The percentage of answers to the questions was evaluated. Differences in indices between groups were calculated using chi-square at the level of .05.

RESEARCH RESULTS

According to the data of the survey, 60.6% pupils indicated that their schools taught them about the Olympic Games. Accordingly, 64.8% girls and 55.9% boys answered so ($x^2 = 19.15$ (1), p = 0.001). The pupils from schools where the programme of the Olympic education was executed indicated that they were taught about the Olympic Games more often compared to the pupils from other schools (accordingly 71.8% and 49.0%, $x^2 = 127.50$ (1), p = 0.001). The data presented in Table 1 show that pupils found out about these Games in history and physical education lessons. It is worth noting that the information about the Olympic Games was mostly rendered in physical education lessons in schools executing the programme of the Olympic education ($x^2 = 149.42$ (1), p = 0.001). Accordingly, the pupils from these schools got information in history lessons more often ($x^2 = 40.86$ (1), p = 0.001). Geography lessons were seldom mentioned by pupils from schools not participating in the programme of the Olympic education ($x^2 = 36.06$ (1), p = 0.001).

Mostly in these lessons pupils were informed about various historic facts of the Olympic Games (OG) (Table 2). The pupils learnt namely these facts more often in schools not participating in the programme of the Olympic education ($x^2 = 44.25$ (1), p = 0.001). On the other hand, in these schools pupils learnt about Olympic participants and champions ($x^2 = 12.65$ (1), p = 0.001) and the symbolism of the Games ($x^2 = 10.05$ (1), p = 0.01) more seldom. Pupils from schools participating in the programme of the Olympic education performed various practical tasks related to the Olympic movement during their lessons, which was not characteristic of pupils from other schools ($x^2 = 6.52$ (1), p = 0.01).

43.5% of the respondents indicated that their schools organized such events as "Olympic day" or "Olympic week". These events were organized in schools executing the programme of the Olympic education more often compared to other schools (accordingly, 64.2% and 22.2% of pupils mentioned these events; $x^2 = 426.69$ (2), p = 0.001). These events included different sports activities (80.7%), but activities related not only to sports, i. e. sport competitions, drawing contests, exhibitions etc., were less often (11.0%). We should note that the

Table 1. **Distribution of lessons indicated by the pupils from the schools participating and not participating in the programme of the Olympic education during which information about the Olympic Games is rendered**

Note. * – p < 0.05; *** – p < 0.001.

Lessons	Schools participating in the programme of the Olympic education, %	Schools not participating in the programme of the Olympic education, %
In all lessons	1.7	0.7*
In physical education lessons	42.1	15.8***
In history lessons	56.7	43.5***
In language lessons	3.0	2.0
In geography lessons	5.3	1.0***
In Olympic tourism lessons	3.0	0
In mathematics, technology lessons	0.9	0.4
In art lessons	2.4	0.4***
In physics, chemistry, biology lessons	1.8	0.2
In ethics, religion lessons	0.3	0.3
In class meetings	0	0.3

Type of schools / Content of Olympic education	Schools participating in the programme of the Olympic education, %	Schools not participating in the programme of the Olympic education %
Learn historic facts about OG	61.6	83.5***
Learn about Olympic participants and champions	6.5	1.2***
Learn about symbolism and traditions of OG	5.7	1.2**
Speak about different sport events	9.5	5.9
Learn about the meaning of OG	4.6	5.6
Speak about fair play and values	2.7	0.3**
Draw, write essays, prepare presentations	2.7	0
Speak about many things related to OG	4.4	2.2

Table 2. **Content of the Olympic education in lessons indicated by the pupils from the schools participating and not participating in the programme of the Olympic education**

Note. The table does not include all answers of pupils what they are taught about the Olympic Games during lessons. * – $p < 0.05$; *** – $p < 0.001$.

Type of schools / Questions	Schools participating in the programme of the Olympic education, %	Schools not participating in the programme of the Olympic education, %
Know the city where the first Modern OG took place	77.8	72.9**
Know when the first Modern OG took place	48.4	30.5***
Know in which city the last winter OG took place	55.7	39.9***
Know in which city the last summer OG took place	80.9	73.2***

Table 3. **Knowledge of pupils from schools participating and not participating in the programme of the Olympic education about the first Modern and last Olympic Games**

Note. The pupils' answers were divided into three groups: right answers, wrong answers and the answer „I do not know". The table only presents the results of the pupils with right answers.
** – $p < 0.01$; *** – $p < 0.001$.

contents of such events were similar irrespective of the school: participating on not participating in the programme of the Olympic education.

The survey showed that 9.4% of pupils irrespective of their sex had personally participated in the national Olympic festival. 18.6% of them indicated that other pupils from their school had participated there. It was established that more pupils who personally participated in those festivals were from schools executing the programme of the Olympic education ($x^2 = 240.07$ (3), p = 0.001). 13.5% of the pupils learning in these schools and only 5.2% of those learning in other schools personally participated in the festivals and 28.5% and 14.5% indicated that other pupils of their schools participated there.

The results of the research revealed that most pupils (75.4%) knew where the first Modern OG took place, but much fewer of them (39.6%) indicated when it took place. Accordingly, lots of them (77.1%) knew in which city the last summer OG took place and it was more difficult for them (47.9%) to indicate the capital of the last winter Games. We want to emphasize that more girls knew the capital of the first modern OG compared to boys (accordingly, 79.9 and 70.3%; $x^2 = 31.66$ (2), p = 0.001). When analyzing the data according to the pupils' age, it was established that older pupils mostly indicated the right capital of the first Modern OG ($x^2 = 23.30$ (4), p = 0.001). The pupils from schools where the programme of the Olympic education was executed knew the place and time of the first modern OG and the last summer and winter Games better (Table 3).

The survey showed less that than half of the schoolchildren (41.6%) irrespective of their sex knew what the Paralympics Games were. It was established the pupils from the schools participating in the programme of the Olympic education knew better about the Paralympics Games compared to

the pupils from other schools (accordingly, 46.0 and 37.0%; $x^2 = 21.60$ (2), p = 0.001).

The results showed that 55.9% of pupils irrespective of their sex were able to indicate some Olympic champions or prize winners. Older pupils knew more of those athletes ($x^2 = 36.02$ (2), p = 0.001). The pupils from schools where the programme of the Olympic education was executed also indicated more of them compared to the pupils from other schools (accordingly, 64.2 and 47.3%, $x^2 = 66.97$ (1), p = 0.001). The pupils who mentioned those athletes were asked to comment why they had chosen those people. Mostly the pupils irrespective of their sex said they just knew those people (40.0%). They mentioned them more often because they were good athletes and fighters (24.2%) or the pride of their country (22.5%). During the survey the pupils were asked to indicate the athletes they disliked. The results showed only 3.3% pupils indicated such athletes.

DISCUSSION

While trying to find out in what way the knowledge related to the Olympic movement was rendered in schools, it we established that pupils mostly learnt about it in physical education and history lessons. That information was rendered in other lessons more often in schools executing the programme of the Olympic education. Art, geography, physics, chemistry and biology lessons can be mentioned as those dealing with Olympism. This data was not unexpected as the integrated programme of the Olympic education for children and young people emphasizes that it is possible to nurture Olympic values and render the knowledge about the world cognition and history of Olympism in physical education and other lessons as well (Gerulskienė, 2007). On the other hand, schools, where the above-mentioned programme was applied, were mostly distinguished by knowledge rendered in physical education lessons.

The survey showed that the contents of the Olympic education were very different in each school. The pupils were acquainted with various historic facts about the Olympic Games, Olympic participants and champions, symbolism, traditions, different kinds of sports of the Olympic Games, the nature of Olympic Games and their meaning, fair play and values, and practical tasks were performed as well (pupils drew, wrote essays and prepared presentations). Besides, various festivals were organized for the pupils: "Olympic day" or "Olympic week". To sum up, it is worth noting that the contents of the Olympic education were more varied in schools where the programme of the Olympic education was executed. On the basis of the research it is not possible determine if other schools did not teach anything about the Olympic movement or Olympism, but they mostly presented various historic facts about the Olympic Games to the pupils and actually did not speak about Olympic values and organized events related to the Olympic movement.

While ascertaining the pupils' knowledge about the Olympic movement and the Olympic Games, it was established that most pupils knew in which city the first Modern and the last summer Olympic Games took place. However, less than one half of the pupils knew the date of the first modern Olympic Games. Our research reflected the tendencies found in other European countries while surveying pupils (Telama et al., 2002; Вацеба, Юхымук, 2007) that older pupils knew the places of the first Modern and the last summer Olympic Games better. It is worth mentioning that 12-year-olds of some surveyed countries did not know the place and date of the first Modern Olympic Games at all.

While analysing the data about pupils from schools participating and not participating in the programme of the Olympic education, we must say that the hypothesis raised at the beginning of the research was confirmed, i. e., the knowledge the first Modern and the last Olympic Games of pupils from schools executing the programme of the Olympic education was better. More pupils from these schools knew about the Paralympics Games. However, less than half of the pupils knew what the Paralympics Games were at all.

The survey revealed that more pupils from the schools executing the programme of the Olympic education knew Olympic champions and prize winners. This data is not surprising as the pupils learnt about Olympic champions in these schools more often, which is not characteristic of other schools. Thus, pupils can get information about them mostly in the media, which is also mentioned by other researchers (Bronikowski, 2006). According to M. Bronikowsky, few pupils get information about the Olympic movement from their coaches and parents.

To sum up, the integrated programme of the Olympic education for children and young people, which has been applied in comprehensive schools of our country for eight years, provides pupils

with knowledge about the Olympic movement. We also assume that the programme of the Olympic education can make the education process more interesting and attractive (Gerulskienė, 2007).

CONCLUSIONS AND PERSPECTIVES

The survey showed that the teachers from schools where the integrated programme of the Olympic education for children and young people was executed integrated the knowledge on Olympism into their teaching subjects. It was established that the contents of the Olympic education varied in these schools: the pupils learnt about various historic facts on the Olympic Games, sportspeople, symbolism and traditions the Olympic Games, fair play, and Olympism-related practical tasks were performed in schools.

The knowledge of pupils from schools executing the integrated programme of the Olympic education for children and young people about the Olympic Games was better compared to the one of pupils from schools not participating in this programme.

Thus, on the one hand, further research should be carried out to find out how much the programme of the Olympic education influences pupils' attitude towards their school and learning. On the other hand, the influence of this programme teaching Olympic values on pupils' behavior should be evaluated, too.

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OLIMPIZMO ŽINIŲ SKLAIDA MOKYKLOJE TAIKANT INTEGRUOTĄ OLIMPINIO UGDYMO PROGRAMĄ

Daiva Majauskienė[1], Saulius Šukys[1], Aušra Lisinskienė[2]
Lietuvos kūno kultūros akademija[1], Kaunas, Lietuva
Batniavos pradinė mokykla[2], Kauno r., Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Straipsnyje gilinamasi į Integruotą vaikų ir jaunimo olimpinio ugdymo programą ir tikrinama hipotezė, kad žinios apie olimpinį judėjimą geresnės tų mokinių, kurių mokykloje vykdoma olimpinio ugdymo programa.

Tikslas: išsiaiškinti olimpizmo žinių sklaidos galimybes mokykloje taikant olimpinio ugdymo programą.

Metodai. Tiriamąją imtį sudarė 2335 13–18 metų šalies mokinių grupė, parinkta dvipakopės tikimybinės atrankos būdu. Tyrimo metu buvo naudotas Olimpinis klausimynas (*Olympic Questionnaire* – Telama et al., 2002). Mokinių klausta, kaip mokykloje perteikiamos olimpinio judėjimo žinios. Aiškinantis mokinių olimpinių žaidynių istorijos žinias klausta apie pirmųjų šiuolaikinių olimpinių žaidynių laiką ir vietą, teirautasi apie paskutines olimpines žaidynes ir klausta, ką jie žino apie parolimpines žaidynes.

Rezultatai. Dažniausiai apie olimpinį judėjimą, olimpines žaidynes mokiniai sužino kūno kultūros ir istorijos pamokose. Nustatyta, kad olimpinio ugdymo turinys yra įvairus: mokiniai supažindinami su istoriniais faktais apie olimpines žaidynes, olimpiečius, aiškinama olimpinių žaidynių simbolika ir tradicijos, kalbama apie garbingą kovą, taip pat atliekami praktiniai darbai, vyksta su olimpizmu susiję renginiai mokykloje. Tyrimas parodė, kad mokinių žinios apie pirmąsias šiuolaikines ir paskutines olimpines žaidynes yra geresnės tose mokyklose, kuriose vykdoma olimpinio ugdymo programa. Daugiau šių mokyklų mokinių žino, kas yra parolimpinės žaidynės.

Aptarimas ir išvados. Nustatyta, kad mokyklose, kuriose vykdoma olimpinio ugdymo programa, mokytojai integruoja olimpizmo žinias į daugelį mokomųjų dalykų. Šių mokyklų mokinių žinios apie olimpines žaidynes yra geresnės.

Raktažodžiai: olimpizmas, integruotas olimpinis ugdymas, mokinių žinios apie olimpinį judėjimą, olimpines žaidynes.

Corresponding author **Daiva Majauskienė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 37 302657
E-mail d.majauskiene@lkka.lt

TIME OF FAST LEARNING IN SPEED-ACCURACY TASKS IS DIFFERENT FOR CHILDREN AND ADULTS

Kristina Motiejūnaitė, Dalia Mickevičienė, Albertas Skurvydas, Kazimieras Pukėnas, Diana Karanauskienė, Sandrija Čapkauskienė
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Motor learning is characterized by specific set of changes in performance parameters which occur gradually over a course of learning period.

Research aim. The aim of the study was to establish and compare the characteristics of learning speed-accuracy movements of children and adults.

Research methods. The research participants were 13 healthy boys, 16 girls, 5 healthy men and 7 women. The research was carried out applying the analyzer of dynamic parameters of human leg and arm movement (DPA-1). We registered maximal and average movement speed, the reaction time and the movement trajectory of the right hand.

Research results. We established significant differences ($p < 0.05$–0.001) in reaction time (RT), average movement speed (Va), maximal movement speed (Vm) and movement trajectory (S) between children and adults.

Discussion and conclusions. Motor adaptation in timescales of minutes is supported by two distinct processes: one process when a person learns slowly from errors but has strong retention, and another process is when a person learns rapidly from errors but has poor retention (Ethier et al., 2008). We might only speculate that children used the second strategy more than adults. The time of fast learning in a speed-accuracy task was different between children and adults. The accuracy was most improved by children at the expense of the quickness, while adults improved only the average velocity of their performance. Besides, most of the variability of performance variables changed more significantly in children than in adults.

Keywords: motor learning, motor control, age, manual task.

INTRODUCTION

Two categories of plastic neural changes in the brain have been established with learning motor skills: those that have focused on early rapid changes occurring over minutes (Karni et al., 1995; Shadmehr, Holcomb, 1997; Maquet et al., 2003; Penhune, Doyon, 2005), and on slowly developing changes occurring over days or weeks (Karni et al., 1995; Kleim et al., 2004; Rosenkranz et al., 2007; Ethier et al., 2008). The results of these studies have shown the involvement of specific regions of motor cortex, the cerebellum and basal ganglia depending of the stage of motor learning. It has been hypothesized that in the cerebellum, early learning is probably

mediated by error-correction mechanisms (Ito, 2001; Penhune, Doyon, 2005), while later it may involve plastic changes in regions of cerebellar hemispheres and / or the cerebellar nuclei specific to the effector and the internal mode for the task (Nezafat et al., 2001).

The acquisition of new motor skill follows two distinct stages with continued practice: first, there is an early, fast learning stage in which performance improves rapidly within a single training session; later, there is a slower learning stage with time period of several sessions of practice (Ungerleider et al., 2002). Motor learning is characterized by specific set of changes in performance parameters (Flament et al., 1999; Kempf et al., 2001). These changes occur gradually over a course of learning period. While the decreases or increases in these parameters have been documented in a variety of tasks, it remains to be determined whether the time course of fast learning is different between children and adults. Therefore the main aim of this study was to establish if there are differences in time course of reaction time, average and maximal velocity and trajectory as well as variability of these variables during 5 series of 20 repetitions in speed-accuracy task.

RESEARCH METHODS

The subjects. 13 healthy boys aged 6.73 ± 0.48 years, body mass – 25.50 ± 4.62 kg, body height – 125.07 ± 7.32 cm; and 16 girls aged 6.50 ± 0.51 years, body mass – 22.87 ± 3.60 kg, body height – 121.81 ± 4.05 cm; as well as 5 healthy men aged 24.60 ± 3.51 years, body mass – 77.01 ± 2.83 kg, body height – 181.80 ± 8.44 cm; and 7 women aged 22.47 ± 1.46 years, body mass – 58.11 ± 4.05 kg, body height – 167.55 ± 3.83 cm participated in the study. The subjects were informed about the course of the study.

Analyzer DPA-1 measuring dynamic parameters of human arm and leg motion. The analyzer contains two measuring devices connected to a stationary standard computer with *Windows* (or compatible to it) operating environment, which has an embedded measurement card with an operating system, and a 17' diameter screen. The measuring device includes the mechanism for transforming handle movement into the measurement zone reduced six times; the mechanism for measuring the coordinates of handle movement; the mechanism for establishing the horizontal component of the module of strength impacting the handle with the

strength measuring element; the electromagnetic mechanism for the development of strength of programmable resistance; the strength measuring unit; the control unit of programmable resistance strength; and power supply.

Measuring devices are fastened to the support panel where the handle units slide on its surface. The power supply switches with the power voltage indicators are fitted in the front of the measuring devices, the connectors for the power cable and the distance control are built-in in the back.

Methods of studying motor learning. During the research the participants are seated in a special chair at the table with a DPA-1 fastened on it. The subject's back is straight and leant at the backrest. Both arms are bent 90^0 at the elbow joint so that the upper arms are nestled against the sides, and the forearms rest on the DPA-1 support panel. The position of the DPA-1 chair is regulated so that the subject could sit comfortably and take a standard position. The distance between the computer screen and the subject's eyes is approximately 0.7 m.

The participants perform the tests with their right arm. In accordance with the tasks of the test prepared in advance, a target – a red circle 0.007 m in diameter – appears on the screen at stated intervals. The distance from the start zone to the target is 0.16 m. The repeated trajectories of arm movements are identical. During each task the subject sets the handle symbol of 0.0035 m in diameter to the start zone (the center of a green circle the diameter of which is 0.01 m) on the computer screen. The program intermittently (every 1–3 s) generates a sound signal and / or a target in the certain place on the computer screen, and the subject has to react to it pushing the handle. The measurement cycle is completed after hitting the target with the circle of the handle symbol. The information about the task performed is stored in the computer memory and later it is transferred to *Microsoft Excel* program.

Motor learning research procedures. The subjects performed a complicated task. They had to react to the target on the computer screen as fast as they could and to push the handle of the device so that the circle of the handle symbol reached the target as fast as possible and followed the most accurate trajectory, and then stopped in it. The target appeared in the same place on the screen. The end-point of the movement was recorded when the center of the handle symbol stopped in the circle and stayed there for no less then 0.03 s. After explaining the task the subjects were allowed

to take three tries, the results of which were not recorded. Then the task was performed in five series, 20 repetitions in each of them. The interval between the series was 2 min, but the repetitions in one series were performed uninterruptedly. We registered maximal (Vm) and average (Va) movement speed, the reaction time (RT) and the movement trajectory (S) of the right hand. After each repetition the subjects could see their achieved result on the computer screen, besides they were motivated verbally to do their best.

Mathematical statistics. The two-way analysis of variance (ANOVA) for repeated measures was used to determine the effect of time (5 series) and age (children vs. adults) on different variables. The one-way analysis of variance (ANOVA) for repeated measures was used to determine the effect of time (5 series) on different variables. If significant effects were found, post hoc testing was performed applying paired t-tests with a Bonferroni correction for multiple comparisons. Descriptive data are presented as means ±SD. The level of significance was set at 0.05. In order to evaluate the relationship between changes in different variables Pearson's correlation coefficient was established. Based on alpha level of 0.01, the sample size (n = 20), standard deviations and

the average level during the first and the fifth series, the statistical power was calculated for all mechanical indicators. Statistical power in all the cases was more than 80 per cent.

RESEARCH RESULTS

We established that there was a significant difference ($p < 0.05$–0.001) in RT, Va, Vm and S between children and adults (Fig. 1, 2, 3, 4). One-way ANOVA shows a significant effect of time (five series: quick learning) in Vm and S of children ($p < 0.01$) and in Va of adults ($p < 0.05$). There was a significant difference in the changes of Va, Vm and S between children and adults (Fig. 5). It is worth noting that S and Vm decreased significantly after the first series and did not change during the 2–5 series while Va increased gradually during all five series in adults.

Figures 6, 7, 8 and 9 show that the variability of all variables of children was significantly greater than that of adults. There were significant changes in the variability (CV) of Va, Vm and S in children, and in the variability of RT in adults. It should be noted that there was no significant difference in CV of Va and S between children and adults during the 2–5 series.
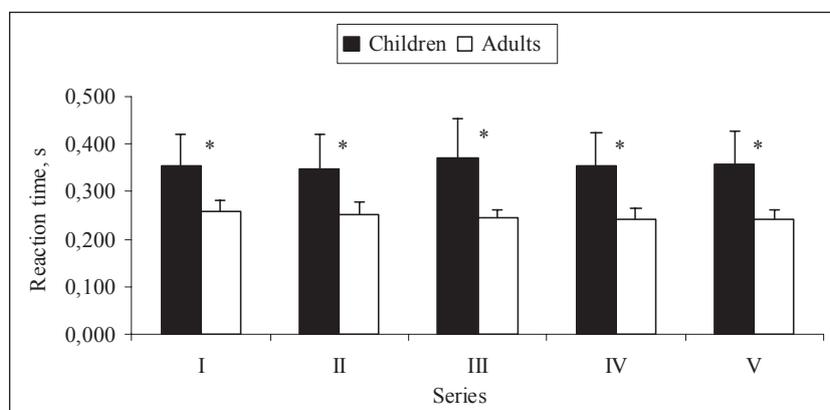

Figure 1. **Changes in reaction time (RT) of children and adults during 5 series of 20 repetitions in the speed-accuracy task**

**Note.** * – $p < 0.001$, between children and adults.
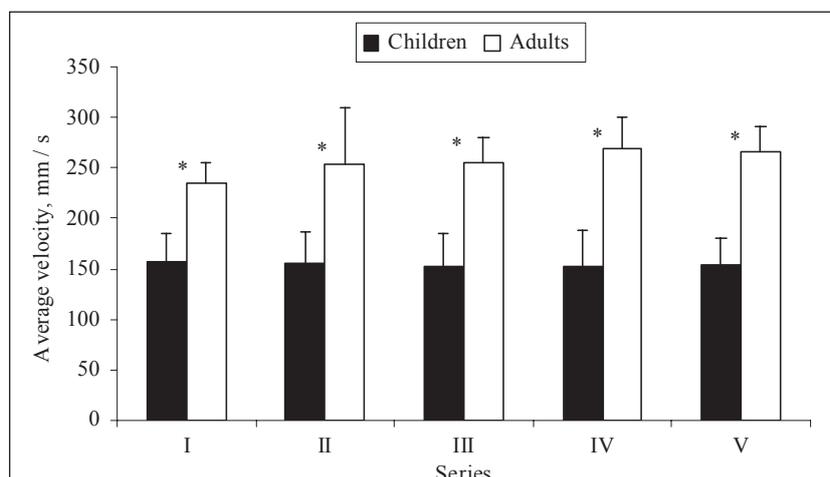
Figure 2. **Changes in average velocity (Va) of children and adults during 5 series of 20 repetitions of speed – accuracy task**

Note. * – $p < 0.001$, between children and adults.

Figure 3. **Changes in maximal velocity (Vm) of children and adults during 5 series of 20 repetitions of speed-accuracy task**
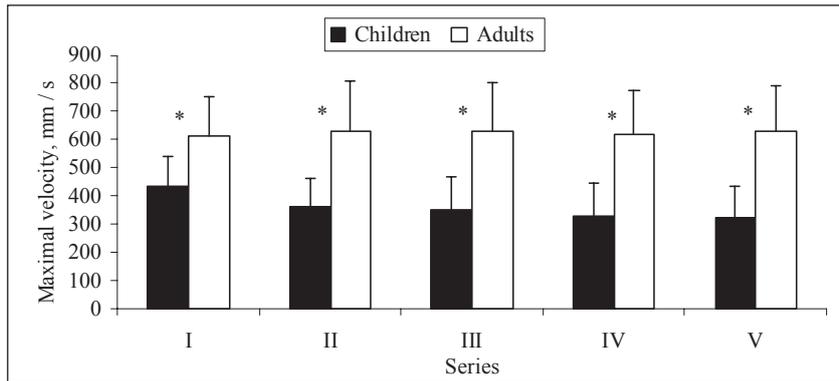
Note. * – p < 0.001 between children and adults.

Figure 4. **Changes in path amplitude (S) of children and adults during 5 series of 20 repetitions of speed – accuracy task**
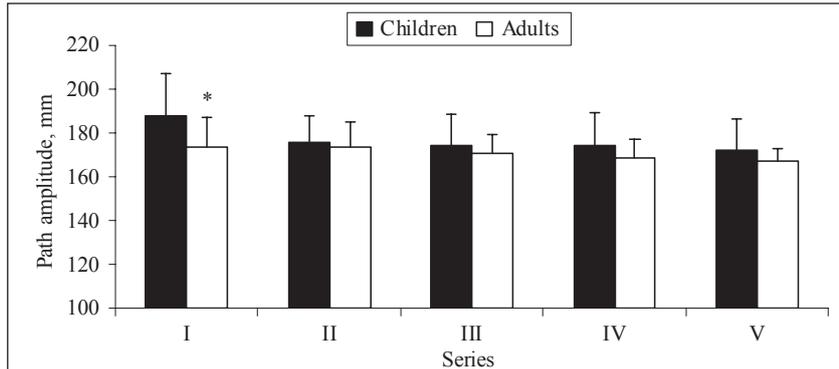
Note. * – p < 0.05 between children and adults.

Figure 5. **Changes in per cent of reaction time (RT), average velocity (Va), maximal velocity (Vm) and path amplitude (S) during 5 series of 20 repetitions of speed-accuracy task**
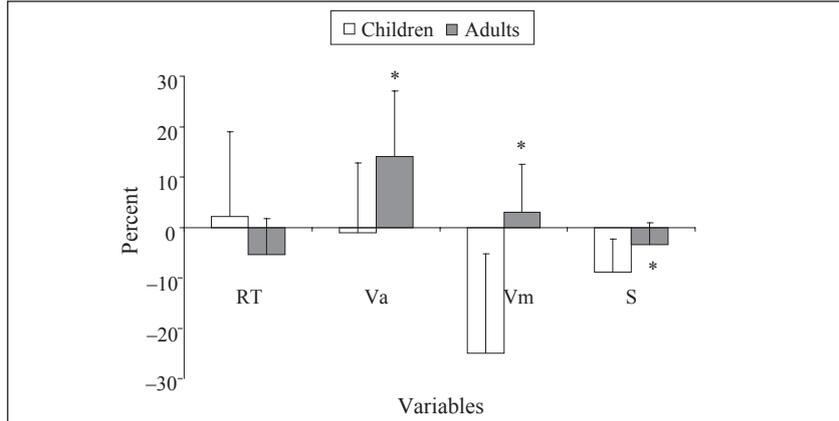
Note. p < 0.05 between children and adults.

Figure 6. **Changes in CV of reaction time (RT) of children and adults during 5 series of 20 repetitions of speed-accuracy task**
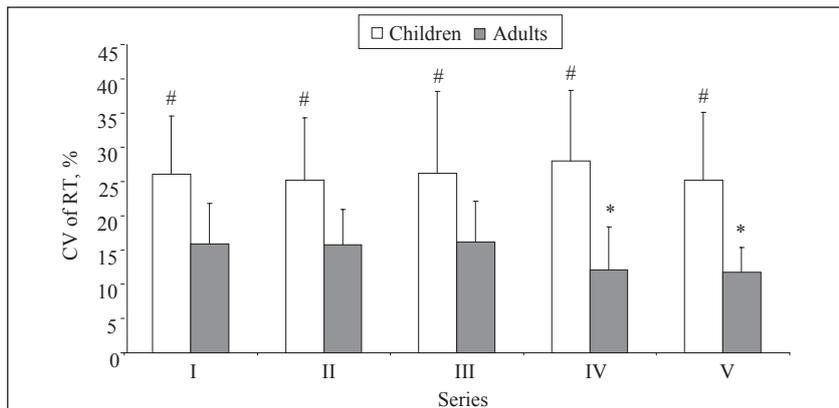
Note. # – p < 0.001 between children and adults; *– p < 0.05, compared to the first series.

We found a significant relationship between the changes in RT and Va of children and adults after five series, r = –0.62 and r = –0.68 respectively. Besides, there was a significant relationship between the changes in S and Vm in children after the second series (r = 0.49).

DISCUSSION

The time difference in the speed-accuracy task variables between children and adults. As far as we know, this is the first study to have shown that the time of fast learning in a speed –
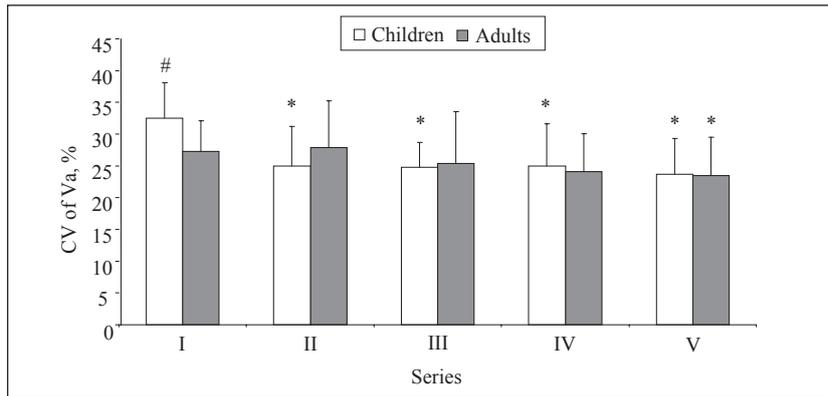
Figure 7. **Changes in CV of average velocity (Va) of children and adults during 5 series of 20 repetitions of speed-accuracy task**

Note. # – p < 0.05 between children and adults; * – p < 0.05, compared to the first series.
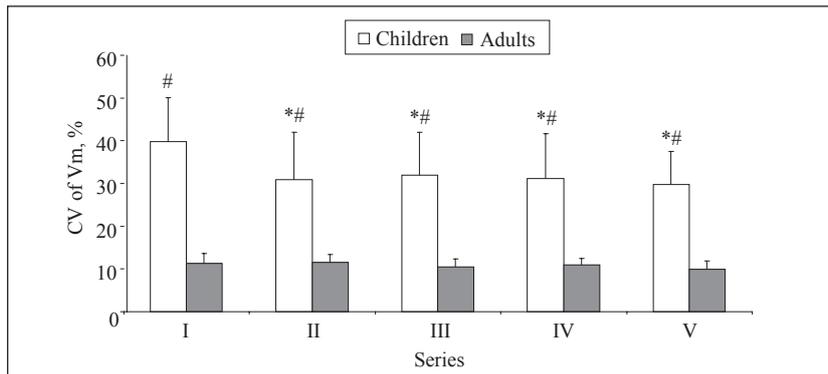
Figure 8. **Changes in CV of maximal velocity (Vm) of children and adults during 5 series of 20 repetitions in the speed-accuracy task**

Note. # – p < 0.001 between children and adults; * – p < 0.05, compared to the first series.
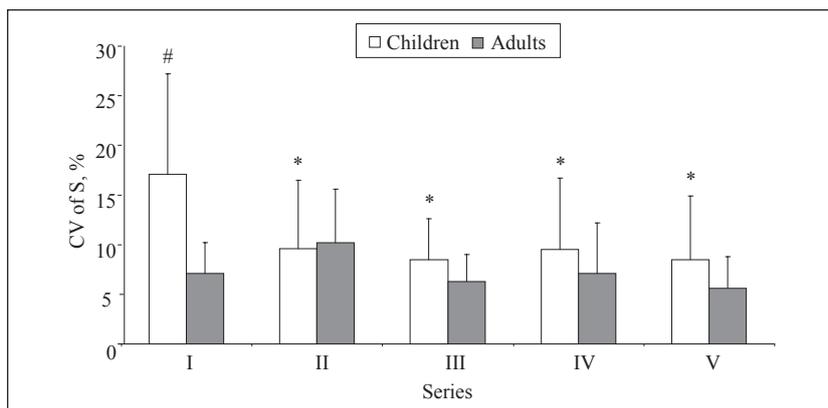
Figure 9. **Changes in CV of path amplitude (S) of children and adults during 5 series of 20 repetitions in the speed-accuracy task**

**Note.** # – p < 0.001 between children and adults; * – p < 0.05, compared to the first series.

accuracy task was different between children and adults. Namely, the accuracy was most improved by children at the expense of quickness, while adults improved only the average velocity of their performance. It might be assumed that fast motor learning process is more expressed in children than in adults. The underlying mechanism for the fast learning difference between children and adults will still have to be elucidated.

These results of our study are in accord with the data of D. Flamment et al. (1999) which suggest that movement parameters change in adult subjects with different time during the process of motor learning (Flament et al., 1999). However, our results have extended this conclusion, i. e. the time of different performance variables is age-dependent (Fig. 6, 7, 8, 9). It has been suggested more specifically that reaction time in adult

subjects was the parameter that changed the fastest and reached a steady baseline earliest while time-related parameters (movement duration) decreased at a somewhat slower rate and plateaued next (Flament et al., 1999). However, there are only Va significant changes during the fast learning period in adult subjects, while RT as well as Vm did not change significantly. This fact is in accord with the data of T. Kempf et al. (2001). They concluded that the movement time was seen to decrease and in a shorter time than peak velocity, which increased and plateaued later.

There were significant changes in the accuracy of the performance in children even after the first series. It might be assumed that children are more prone to develop motor skills during the fast learning period. However, it is not clear why children used the strategy of improving accuracy

at the expense of quickness. It is important to note that in our study the changes in RT and Va correlated significantly in children, as well as in adults. This means that two different variables changed consistently. Besides, we found that changes in S and Vm correlated directly in children. In other words, the more S decreased, the more Vm decreased.

It has been concluded that motor adaptation in timescales of minutes is supported by two distinct processes: one process when a person learns slowly from errors but has strong retention, and another process is when a person learns rapidly from errors but has poor retention (Ethier et al., 2008). We might only assume, that children used the second strategy more that adult, i. e. they learnt rapidly but had poor retention.

The difference between children and adults in the variability of time of the speed-accuracy task. We established that the variability of Va, Vm and S changed significantly after the first series only in children while in adults only the variability of RT gradually decreased. It has been recently concluded that the variability of task performance was more expressed in children than in adults (Kuhtz-Buschbeck et al., 1998; Yan et al., 2000; Jansen-Osmann et al., 2002). This is in accord with the results of our study. We have not come, however, across any publications devoted to the study of differences between children and adults in the variability of time of the speed-accuracy task. Therefore, as far as we know, this is the first study have shown that children were more prone for changes not only in accuracy but in the variability of accuracy, as well as in Va and Vm. It is rather surprising that the variability of RT did not change during the fast learning period in children. It has been proposed that during fast learning motor models are developed in children and adults (Jansen-Osmann et al., 2002). The authors concluded that the neural representations of limb dynamics are less precise in children and less stable in time than those of adults. Therefore, such controller instability might be a primary cause of more variability of performance variables in children compared to adults in our study. It has been, recently, concluded that on-line optimization of movement would depend on the proposed cerebellar mechanisms such as, feed-forward and error correction (Nezafat et al., 2001), development of internal models (Shadmehr, Holcomb, 1997; Wolpert et al., 2001; Cothros et al., 2006; Imamizu et al., 2007).

CONCLUSIONS AND PERSPECTIVES

In conclusion, the time of fast learning in speed-accuracy task was different between children and adults. Namely, the accuracy was most improved by children at the expense of the quickness, while adults improved only the average velocity of their performance. Besides, most of the variability of performance variables changed more significantly in children than in adults. It might be speculated that children are more prone to change motor variables during the fast learning process than adults. Though the underlying mechanism for the fast learning difference between children and adults have to be elucidated, yet it might be speculated that feed-forward and error correction mechanisms as well as the development of internal models are more changeable in children than in adults during the fast learning process.

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VAIKŲ IR SUAUGUSIŲJŲ GREITO IŠMOKIMO TRUKMĖ ATLIEKANT GREITUMO IR TIKSLUMO UŽDUOTIS

Kristina Motiejūnaitė, Dalia Mickevičienė, Albertas Skurvydas, Kazimieras Pukėnas, Diana Karanauskienė, Sandrija Čapkauskienė
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Mokantis judesių įvairiais mokymosi tarpsniais kinta judesių rodikliai.

Tikslas: nustatyti bei palyginti vaikų ir suaugusiųjų greitumo, tikslumo judesių mokymosi ypatybes.

Metodai. Buvo tiriama 13 sveikų berniukų, 16 mergaičių, 5 sveiki vyrai ir 7 moterys. Tyrimas atliktas Lietuvos kūno kultūros akademijos Judesių valdymo laboratorijoje naudojant žmogaus rankų ir kojų dinaminių rodiklių analizatorių (DPA-1). Užduotį tiriamieji atliko dešine ranka. Jie turėjo kuo greičiau reaguoti į kompiuterio ekrane pasirodantį taikinį ir kaip galima greičiau bei tiksliau į jį pataikyti. Buvo registruojamas dešinės rankos maksimalusis ir vidutinis judesio greitis, reakcijos trukmė ir judesio trajektorija.

Rezultatai. Nustatyta reikšmingų skirtumų (p < 0,05–0,001) tarp vaikų ir sauaugusiųjų reakcijos trukmės, vidutinio greičio, maksimaliojo greičio ir judesio trajektorijos rodiklių.

Aptarimas ir išvados. Motorinė adaptacija bėgant laikui pasireiškia dviem skirtingais vyksmais: kai asmuo mokosi lėtai iš klaidų ir ilgai atsimena; kai asmuo mokosi iš klaidų greitai, tačiau greitai ir pamiršta (Ethier et al., 2008). Manome, kad vaikai antrą strategiją naudoja dažniau nei suaugusieji. Atliekant greitumo ir tikslumo užduotį vaikų ir suaugusiųjų mokymasis skiriasi. Vaikų tikslumas gerėjo greitumo sąskaita, o suaugusiųjų padidėjo tik vidutinis judesio greitis. Be to, užduotį atliekant vaikams daugumos kintamųjų kaitumas pasikeitė statistiškai reikšmingiau nei tai darant suaugusiesiems.

Raktažodžiai: judesių mokymasis, judesių valdymas, amžius, užduotis rankoms.

Corresponding author **Kristina Motiejūnaitė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 37 302645
E. mail kmotiejunaite@yahoo.com

RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND HEALTH-RELATED PHYSICAL FITNESS IN 16-YEAR-OLD BOYS

Renata Rutkauskaitė, Arūnas Emeljanovas, Vida Volbekienė, Rita Sadzevičienė, Edita Maciulevičienė, Olegas Batutis, Rita Gruodytė
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. It is well established that regular physical activity (PA) has many short- and long-term benefits for children's health. Physically active children are more physically fit than their physically inactive counterparts. Insufficient physical fitness of adolescents is one of the risk factors for chronic diseases and has a tendency to be carried over into adulthood.

Research aim was to examine health-related physical fitness in low, moderate and vigorous physical activity categories among 16-year-old schoolboys.

Research methods. The participants were 155 healthy schoolboys of the 10th grade from secondary schools of Kaunas (Lithuania). Their physical activity was measured by a modified short form of the International PA Questionnaire (IPAQ) (Craig et al., 2003). The respondents were divided in three PA categories: high (vigorous) (VPA) (n = 43), moderate (MPA) (n = 63), and low (LPA) (n = 49). Physical fitness tests were performed to measure participants' flexibility (by sit-and-reach test) (Eurofit, 1993), power (by vertical jump test), and muscular strength and endurance (by modified push-up test) (Suni et al., 1994).

Research results. There were no significant differences between the boys in different PA groups in respect of anthropometrical and body composition parameters ($p > 0.05$). The results of health-related physical fitness tests were significantly better of the VPA group boys ($p < 0.05$). The total volume of PA correlated with all health-related physical fitness components that were measured ($r = 0.23–0.38$, $p < 0.01$).

Discusion and conclusions. We may conclude that health-related physical fitness is positively related to the total amount of physical activity in 16-year-old schoolboys.

Keywords: frequency, duration, intensity, volume, physical activity, physical fitness.

INTRODUCTION

Every organism is a complex, dynamic, and self-regulating system the functioning of which depends on the efficiency of numerous components (Kauffman, 2000). Similarly, people's health depends on a complex of many factors of which physical activity (PA) is playing its own important role. Physical activity is suggested to be an essential part of everyday life, especially during growth and rapid development of school-aged children. The benefits of PA are numerous: it has a positive effect on the prevention of various diseases in schoolchildren (Dencker, Andersen, 2008), improves numerous aspects of emotional well-being (Burdette, Whitaker, 2005),

has influence on their cognitive development (Dencker et al., 2006), increases self-esteem and controls the levels of anxiety and stress, and certainly it affects the level of physical fitness (PF) (Malina, Katzmarzyk, 2006). F. B. Ortega et al. (2008 b) confirm the significant correlations between the level of physical fitness and morbidity and mortality rates caused by chronic diseases. PF is an important factor of health (Lohman et al., 2008). It has been suggested that physical fitness is an integrated dimension of most, if not all, functions of organism related with physical activity (Ortega et al., 2008 b). Indeed, the majority of physiological functions are estimated during physical fitness tests. The level of physical activity and physical fitness in childhood and adolescence has an influence on health status in adulthood (Gordon-Larsen et al., 2004; Matton et al., 2006). Components of physical fitness such as agility, balance, coordination, speed or reaction time are directly related with sport results and achievements rather than the state of health. Health-related physical fitness (HRPF) components are cardiovascular endurance, muscular strength and endurance, flexibility and body composition (Ortega et al., 2008). Recently, explosive power has been attributed to it as well.

The level of HRPF of schoolchildren in Lithuania and all over the world is decreasing and the tendencies of it's change are negative. The number of children with overweight in Europe and USA is increasing (Currie et al., 2004). Although overweight or obesity are not common among Lithuanian children yet (Currie et al., 2004), evidence exists that overweight in children prevails when acceleration rate has stabilized or even decreased. As well schoolchildren' cardiovascular and muscular capacity is unsatisfactory and has a tendency to decrease. Our previous study has indicated a significant decrease of HRPF level in Lithuanian adolescents over the years 1992–2002, especially

in cardiovascular endurance and flexibility (Volbekiene, Griciute, 2007).

Studies justify the relationships between physical activity and health, but research on the relationship between physical activity and health-related physical fitness remains problematic. The most important studies are focusing on the dose-response relationship between physical activity and various health components (Rankinen, Bouchard, 2002; Lee, 2007). Moderate PA is recommended for adult population, while children and youth should experience moderate-to vigorous PA. However, the evidence, based on longitudinal studies justifying the benefit of vigorous PA on health and physical fitness of children and adolescents, is still lacking. Furthermore, the steadily decreasing levels of PA of children and adolescents are a matter of great concern for their health and physical fitness in the future. **The aim** of the study was to investigate the relationship between physical activity and health-related physical fitness of 16–year-old boys.

RESEARCH METHODS

The study was performed in March–April 2009 in seven secondary schools of Kaunas (Lithuania) with the following restrictions, i. e. schools for national minorities and schools situated in the periphery of the city were not included. The convenient sample of this study consisted of 191 schoolboys of the 10th grade (about of 16 years old). All of the participants were of the regular Physical Education group according to their health status. Schoolboys (n = 155) who fulfilled all requirements of the study (e. g. they voluntary agreed to take part in the tests; their parents or foster parents gave written informed consent; they provided all necessary data for calculating the total amount of physical activity in the questionnaire and performed all of the given physical fitness tests) were selected for the statistical analysis. The study was carried out in two stages: 1) physical

Groups	n	Age, years	Height, cm	Body mass, kg	BMI
Low PA	49	16.2 ± 0.5	178.9 ± 6.6	65.6 ± 10.1	20.5 ± 2.5
Moderate PA	63	16.2 ± 0.5	181.5 ± 7.0	71.2 ± 13.0	21.6 ± 3.2
High PA	43	16.3 ± 0.5	181.6 ± 5.1	70.2 ± 8.9	21.0 ± 2.6
Total	155	16.2 ± 0.5	180.7 ± 6.5	69.1 ± 11.3	21.1 ± 2.9
F		0.66	2.81	3.79	2.05
p		> 0.05	> 0.05	< 0.05	> 0.05

Table 1. **Characteristics of the study population (mean ± SD)**

Note. PA – physical activity; BMI – body mass index.

activity measurements in March, and 2) health-related physical fitness testing in April.

Physical activity of schoolboys was measured using the Short Form of International Physical Activity Questionnaire (IPAQ)(Craig et al., 2003). The data of intensity (METs), frequency (days / week) and duration (minutes / day) of vigorous, moderate and low (walking) physical activity that lasted for at least 10 minutes at a time was used to calculate the total amount of PA during one week (MET-minutes / week). According to the level of the total amount of PA and following the "*Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) Short and Long Forms*" (2005), all of the participants were divided into 3 groups: low PA ($\leq$ 1387 MET-minutes / week), moderate PA ($> 1387 < 3001$ MET-minutes / week) and high PA ($\geq$ 3001 MET-minutes / week). Characteristics of the study population are presented in Table 1.

Health-related physical fitness was estimated by measuring the following components:

1) body composition by calculating BMI (kg / m²) from height (cm) and body mass (kg) data;

2) explosive power of leg muscles by performing vertical maximal jump (cm) with countermovement on *Kistler* contact platform, analyzing results with BioWare Performance Software Version 3.0, and registering the best result from three attempts;

3) muscular strength and endurance of arms and trunk by modified push-up test (n / 40 seconds) (Sunni et al., 1994).

4) flexibility by sit-and-reach test (cm) (Eurofit, 1993).

All participants were informed about the aim of the study, the content of the questionnaire as well as process of filling it in, and the methodology of HRPF test performance. The interview for IPAQ and the HRPF tests were conducted by a specially trained team of qualified testers. The research was carried out under the mutual agreements between the Lithuanian Academy of Physical Education and secondary schools aiming at investigating the levels of physical activity and physical fitness of schoolchildren.

Statistical analysis of the results was performed using computer programs *MS Excell* and *SPSS*. Appropriate statistical methods were used to calculate means and standard deviations ($\pm$ SD), one-way analysis of variance (ANOVA) and Tukey

post hoc test were used to establish the differences among the groups. The relationships between physical activity and HRPF components were identified using Pearson's correlation analysis. A significance level of 0.05 was used.

RESEARCH RESULTS

Physical activity. The total amount of physical activity (i. e. energy expenditure during one week) of 16-year-old boys on average was 959.0 MET-minutes / week in low PA group, 2056.7 MET-minutes / week in moderate PA group and 3548.8 MET-minutes / week in high PA group. The frequency, duration and total amount of vigorous physical activity (VPA) of the whole group are presented in Table 2. The dominant frequency of VPA is 2–3 days / week. The duration of PA ranged from 28.6 minutes per 1 day to 42.4 minutes per 3 days. The greatest energy expenditure (809 kcal / week) was when VPA frequency was seven days per week.

The significant differences were found between the boys of high and low PA groups in respect of vigorous PA: the mean frequency and duration of VPA were 4 days / week and 46 minutes / day vs. 1.5 days/week and 14 minutes/day, respectively ($p < 0.001$).

The frequency, duration and total amount of moderate physical activity (MPA) of the whole group iare presented in Table 3.

The dominant frequency of MPA is 2–3 days / week. The duration of PA ranged from 25.5 minutes per 7 days to 45.8 minutes per 6 days. The greatest energy expenditure (700 and 908 kcal/ week) was when MPA frequency was five and six days per week.

The dominant frequency and duration of walking in the whole group were seven days per week and 40.8 minutes per day, respectively (Table 4). Everyday walking with energy expenditure of 943 kcal / day was experienced by 56.1% of schoolboys. The mean frequency and duration of walking activities were the greatest of the boys of the high PA group (6.6 days / week and 52.8 minutes / day, respectively; $p < 0.05$). The greatest amount of time spent for sitting activities was of the boys of the low PA group (approximately 9.3 hours / day, $p < 0.05$).

Health-related physical fitness in different physical activity groups. There were significant differences in HRPF tests results among the different physical activity groups, i. e. in all cases

Frequency, days / week	Duration, minutes / day	Total amount, kcal / week)	Respondents	
			%	n
0	0	0	18.1	28
1	28.6 ± 15.9	94 ± 53	7.1	11
2	29.7 ± 13.8	196 ± 91	18.7	29
3	42.4 ± 21.3	420 ± 209	20.0	31
4	37.0 ± 20.5	488 ± 271	16.1	25
5	37.1 ± 16.4	612 ± 270	12.3	19
6	33.5 ± 12.9	663 ± 256	6.5	10
7	35.0 ± 7.1	809 ± 163	1.3	2
Total			100	155

Table 2. **Frequency, duration and total amount of vigorous physical activity**

Note. Data presented as mean ± SD.

Frequency, days / week	Duration, minutes / day	Total amount, kcal / week)	Respondents	
			%	n
0	0	0	2.6	4
1	35.0 ± 32.0	116 ± 106	5.8	9
2	42.1 ± 24.6	278 ± 163	22.6	35
3	42.1 ± 28.8	417 ± 285	21.3	33
4	37.6 ± 20.2	497 ± 267	13.5	21
5	42.4 ± 21.8	700 ± 360	17.4	27
6	45.8 ± 23.6	908 ± 468	7.7	12
7	25.5 ± 17.9	649 ± 418	9.0	14
Total			100	155

Table 3. **Frequency, duration and total amount of moderate physical activity**

Note. Data presented as mean ± SD.

Frequency, days / week	Duration, minutes / day	Total amount, kcal / week)	Respondents	
			%	n
0	0	0	0.6	1
1	30.0 ± 20.0	99 ± 66	1.9	3
2	59.1 ± 48.8	390 ± 322	7.1	11
3	47.8 ± 28.2	473 ± 279	5.8	9
4	22.9± 10.8	302 ± 142	4.5	7
5	33.2 ±23.3	548 ± 385	14.2	22
6	34.3 ± 19.2	680 ± 380	9.7	15
7	40.8 ± 23.7	943 ± 547	56.1	87
Total			100	155

Table 4. **Frequency, duration and total amount of walking**

Note. Data presented as mean ± SD.
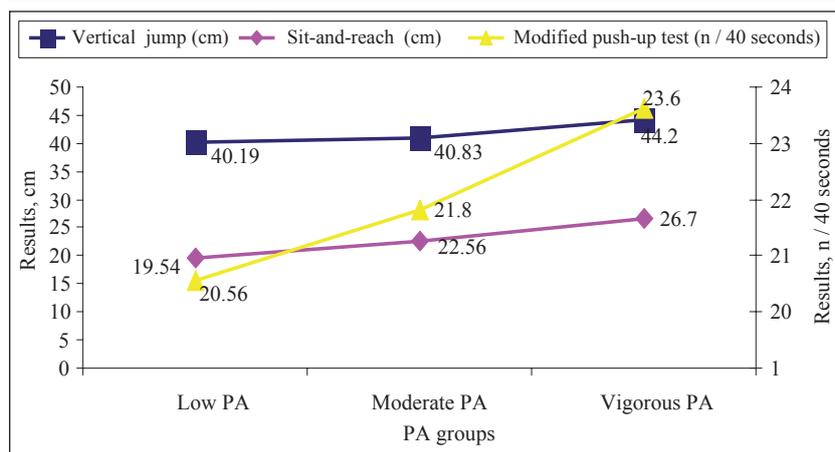
Figure. **Health-related physical fitness results in low, moderate and high PA groups**

Note. * – difference from high PA group, p < 0.05.

the better results were in higher physical activity groups (F = 11.39–5.56; p < 0.05) (Figure). The boys of high PA group demonstrated the best results in all measured components: explosive power (the mean of vertical maximal jump was 44.2 cm), flexibility (the mean sit-and-reach test result was 26.7 cm), and muscular strength and endurance of arms and trunk (the mean result was 23.6 push-ups in 40 seconds).

Relationship between physical activity and health-related physical fitness. There were weak to moderate significant correlations between physical activity and HRPF components. The total amount of physical activity (kcal/week) correlated to explosive power of leg muscles (r = 0.23; p < 0.0l), muscular strength and endurance of arms and trunk (r = 0.38; p < 0.01), and flexibility (r = 0.38; p < 0.01).

DISCUSSION

It has been well established that regular physical activity (PA) has many short- and long-term benefits for children's health (Katzmarzyk, Craig, 2006). Despite these benefits many children and adolescents do not engage in recommended amounts of physical activity (Jago et al., 2005). Daily moderate-to-vigorous physical activity for at least 60 minutes is suggested to be health-enhancing and recommended by experts for children and adolescents (Oja et al., 2010).

The results of our study indicated that the dominant frequency of moderate physical activity was two to three days per week and only for 43.9% of 16-year-oldd schoolboys. Moderate PA on everyday basis was experienced by 9% of the respondents with mean duration of about 26 minutes / day only.

Physically active children are more physically fit than their physically inactive counterparts. Insufficient physical fitness of adolescents is one of the risk factors for chronic diseases and has a tendency to be carried over into adulthood (Gordon-Larsen et al., 2004; Matton et al., 2006). In our study, when comparing different physical activity groups, the results of all HRPF tests were significantly better in higher physical activity groups. Boys with higher levels of physical activity have greater explosive power of leg muscles, muscular strength and endurance of arms and trunk, and flexibility. The same tendency was found in our previous study (Volbekienė et al., 2008).

Although physical fitness is greatly dependant on genetical heredity, daily physical activity and health status are also related to it (Malina et al., 2004). Numerous epidemiological studies indicate positive influence of physical exercise on cardiovascular capacity and functional status (Myers et al., 2004; Macera et al., 2003). Many studies emphasize positive effects of exercise on cardiovascular (Baquet et al., 2006; Dollman, Olds, 2007) and muscular fitness (Horst et al., 2007).

Physical activity correlates positively with physical fitness and negatively with fat mass and risk factors for cardiovascular system in children and adolescents (Ortega et al., 2008 b). As the boys of high physical activity group in our study demonstrated significantly better results in all of the HRPF tests and positive correlations of the total amount of physical activity were found with all HRPF components ($r = 0.23–0.38$), we may suggest that physical activity positively influences health-related physical fitness of 16-year-old boys. This corresponds well with the findings of other studies indicating that physical activity affects physical fitness (Emeljanovas, Poderys, 2010; Wilmore, Costill, 2001). The correlations between physical fitness and physical activity found in our study were weak to moderate. Other studies with children and adolescents report the same tendency (Malina et al., 2004; Oja et al., 2010).

CONCLUSIONS AND PERSPECTIVES

Adolescent boys with greater amounts of physical activity have significantly greater explosive power of leg muscles, muscular strength and endurance of arms and trunk, and flexibility. The total amount of physical activity positively correlates with health-related physical fitness components (such as explosive power of leg muscles, muscular strength and endurance of arms and trunk, and flexibility) in 16-year-old boys. Although the preliminary results of this study indicate the relationship between PA and HRPF in schoolboys, further investigation is required to test our findings.

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ŠEŠIOLIKAMEČIŲ BERNIUKŲ FIZINIO AKTYVUMO IR SU SVEIKATA SUSIJUSIO FIZINIO PAJĖGUMO RYŠIAI

Renata Rutkauskaitė, Arūnas Emeljanovas, Vida Volbekienė, Rita Sadzevičienė, Edita Maciulevičienė, Olegas Batutis, Rita Gruodytė
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Tyrimais nustatyta, kad reguliarus fizinis aktyvumas (FA) turi trumpalaikį ir ilgalaikį teigiamą poveikį sveikatai. Vaikai, patiriantys didesnį fizinį aktyvumą, yra fiziškai pajėgesni (FPj) nei mažiau fiziškai aktyvūs jų bendraamžiai. Nepaisant to, vis dar labai daug vaikų yra nepakankamai fiziškai aktyvūs. O pasyvi gyvensena, nepakankamas FPj vaikystėje ir paauglystėje gali būti vienu iš rizikos veiksnių susirgti įvairiomis lėtinėmis ligomis suaugus.

Tikslas: nustatyti 16 metų berniukų su sveikata susijusį fizinį pajėgumą mažo, vidutinio ir didelio fizinio aktyvumo grupėse.

Metodai. 155 dešimtos klasės mokiniai, įvykdę visus būtinus tyrimo reikalavimus, buvo atrinkti iš Kauno miesto bendrojo lavinimo mokyklų. Fizinis aktyvumas (FA) nustatytas pagal modifikuotą tarptautinio FA (IPAQ) klausimyno trumpąją formą (Craig et al., 2003). Visi respondentai pagal bendrąją FA apimtį buvo suskirstyti į 3 grupes: mažo (n = 49), vidutinio (n = 63) ir didelio FA (n = 43). Fizinis pajėgumas nustatytas matuojant lankstumą (*Eurofit*, 1993), kojų raumenų staigiąją jėgą (matuokliu SBM-1), rankų ir liemens raumenų ištvermę (Suni et al., 1994).

Rezultatai. Tiriamųjų antropometriniai duomenys ir kūno kompozicija statistiškai reikšmingai nesiskyrė tarp skirtingo fizinio aktyvumo grupių (p > 0,05). Geresnių su sveikata susijusio fizinio pajėgumo rezultatų pasiekė mokiniai, priskirti didelio fizinio aktyvumo grupei (p < 0,05). Nustatyti teigiami silpni ryšiai tarp mokinių bendrosios fizinio aktyvumo apimties ir su sveikta susijusio fizinio pajėgumo rodiklių (r = 0,23–0,38; p < 0,01).

Aptarimas ir išvados. 16 metų amžiaus grupės berniukų su sveikata susijęs fizinis pajėgumas ir bendrojo fizinio aktyvumo apimtis yra susiję teigiamais koreliaciniais ryšiais.

Raktažodžiai: fizinio aktyvumo dažnumas, trukmė, intensyvumas, fizinis pajėgumas.

Corresponding author **Renata Rutkauskaitė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 67409104
E-mail r.rutkauskaite@lkka.lt

INTER-LIMB COORDINATION VARIABILITY IN ICE CLIMBERS OF DIFFERENT SKILL LEVEL

Ludovic Seifert[1], Leo Wattebled[1], Maxime L'Hermette[1], Romain Herault[2]
University of Rouen[1], Faculty of Sports Sciences, France
National Institute of Applied Sciences (INSA)[2], Rouen, France

ABSTRACT

Research background and hypothesis. Ice climbers determine their own ascent paths by creating holes with their crampons and ice tools. The coupling of upper and lower limbs thus emerges from the icefall environment without prescriptions for one mode of coordination.

Research aim. The aim of this study was to analyse the upper / lower limb coordination of ice climbers of different skill level and to explore how the environmental constraint (ice fall shape) is used by the climbers to adapt their motor behaviour.

Research methods. Six elite ice climbers and five beginners climbed a 30m icefall, respectively in grade 5 / 5+ and grade 4. Frontal camera videotaped the first 15m of the ascent, then the left and right ice tools and the left and right crampons were digitalised in order to analyse the upper limbs coupling, the lower limbs coupling and the upper / lower limb coordination.

Research results. The results indicated that in-phase mode of upper / lower limb coordination was the main attractor for both groups. However, elite climbers showed greater variability in their behaviour, exploring larger range of upper and lower angles (particularly vertical and crossed positions) and types of movement (ice tool swinging and ice hole hooking).

Discussion and conclusions. It was concluded that holes in ice fall, and more globally ice fall shape, were affordances that induced variable upper / lower limb coordination in elite climbers, whereas beginners used a basic and stable motor organization in order to maintain body equilibrium.

Keywords: upper / lower limb coordination, environmental constrains, types of movement.

INTRODUCTION

Rock climbing is a complex skill imposing postural constraints to grasp holds. C. Bourdin et al. (1999) postulated that high postural constraints lead to a re-organization of the grasping movement by decreasing the duration of the movement up to contact, in order to maintain equilibrium. In other words, the climbers usually try to minimize the duration of the tripodal position by fast hold grasping, whatever the complexity of the hold to grasp. In ice climbing (climbing with ice tools and crampons on frozen water fall), the climbers could either swing their ice tool to create their own hole or use an existing hole (due to previous climbs or natural hole). The ice tool swinging involved a tripodal position that could take more

or less time as regards the number of ice tool swinging done by the climber. Thus, ice climbing could correspond to an alternation between ice tool swinging, crampon kicking and arm pulling associated to leg pushing. As rock and ice climbing correspond to complex skill involving both upper and lower limbs, the climbers have to organize their coupling in order to maintain equilibrium and to travel a great distance between each ice tool swinging and crampon kicking.

Studies of inter-limb coordination during oscillating on a ski simulator (Vereijken et al., 1992), volley ball serve (Temprado et al., 1997), or swimming (Seifert et al., 2010) showed that beginners freeze the degrees of freedom while expert release the degrees of freedom not useful to the task. Freezing the degrees of freedom is mostly related to a basic coordination mode like in-phase (reflecting iso-direction or iso-contraction of two limbs; Swinnen et al., 1997), while releasing the degrees of freedom corresponds to out-of-phase, notably the anti-phase coordination mode (Vereijken et al., 1992; Temprado et al., 1997; Seifert et al., 2010).

Ice climbers determine their own ascent paths by creating holes with their crampons and ice tools. The coupling of upper and lower limbs thus emerges from the icefall environment without prescriptions for in- or out-of-phase. The aim of this study was to analyse the upper / lower limb coordination of ice climbers of different skill level in order to explore how the existing holes in the icefall act as affordance for the climbers. It has been hypothesized that beginners mostly

show an in-phase mode, being static for a long time or swinging too much with their ice tools. Conversely, the expert climbers would have their two ice tools asymmetric to travel great distance at each arm pulling, favouring out-of-phase coupling of upper / lower limbs.

RESEARCH METHODS

Participants and protocol. Six elite ice climbers (UIAGM mountain guides and instructors at the National School of Skiing and Alpinism – ENSA, climbing regularly at grade 6 climbed a 30m icefall at grade 5/5+ on the French rating scale (which goes from 1 to 7) (Batoux, Seifert, 2007). Six beginners (students at the Faculty of Sport Sciences with 20 hours of practice in wall climbing and inexperienced at ice climbing) climbed a 30m icefall at grade 4. All climbers were equipped with the same crampons and ice tools and were instructed to climb at their normal pace. The protocol was fully explained to the participants and they provided written consent to participate in the study, which was approved by the university ethics committee.

Data collection and analysis. A frontal camera (50 Hz) videotaped 15 m of the ascent (between 5 m and 20 m); this camera was placed at 15 m of the ice fall. A calibration frame delimited the recorded space of climbing and was composed of one vertical rope with marks every 2 m and two horizontal ropes (at 5 m and at 20 m) with marks every 1m (total of 20 marks for calibration). Four key points (the head of the left

Figure 1. **Angle between horizontal position, the left and the right limbs**
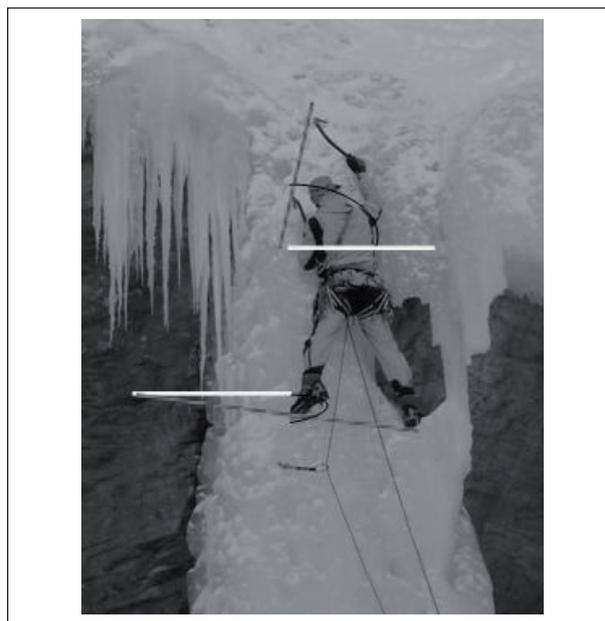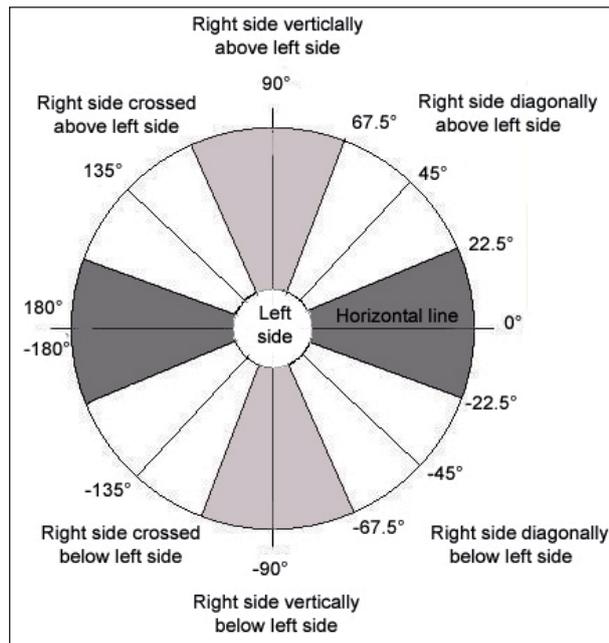
Figure 2. **Angle between horizontal position, the left limb and the right limb**
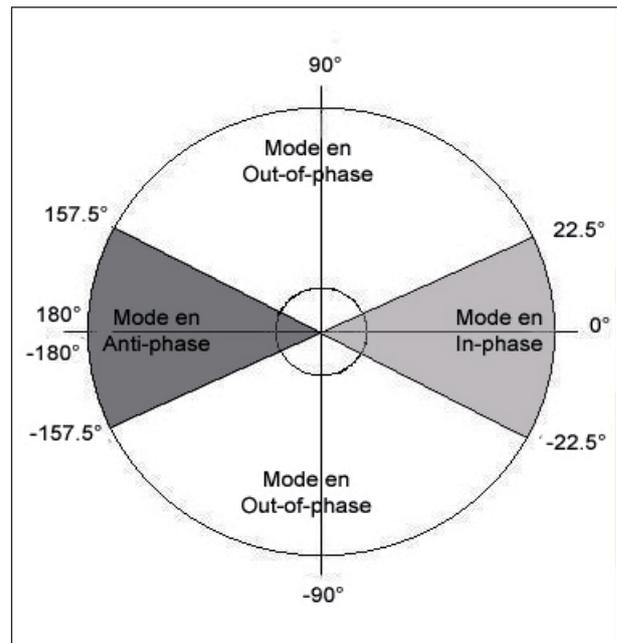

Figure 3. **Upper / lower limb coordination mode**

and the right ice tools and the extremity of left and right crampons) were digitalised using *Simi Reality Motion Systems GmbH ®,* 2004. Upper limb coupling was assessed by the angle between the horizontal line and the left and right ice tools, while lower limb coupling corresponded to the angle between the horizontal line and the left and right crampons (Fig. 1).

Thus, the angle between the horizontal line and the left and right limbs was positive when the right limb was above the left limb and negative when the right limb was below the left limb (Fig. 2).

The phase angles of the upper and lower limbs were obtained by Hilbert transform (Matlab 7.7 ® 1984–2008, The MathWorks, Inc.), usually calculated for non-periodic signals (van Emmerik et al., 2004; Balasubramaniam, Turvey, 2004; Palut, Zanone, 2005). Phase = arctan s (t) / iH (t), with s (t) as the real part and iH (t) the imaginary part of the signal. In our case, continuous relative phase (CRP) for upper / lower limb coordination corresponded to: CRP = arctan [H_{upper}(t) · s_{lower}(t) − s_{upper}(t) · H_{lower}(t)] / [s_{upper}(t) · s_{lower}(t) − H_{upper}(t) · H_{lower}(t)]. In-phase mode was assumed to occur for −22.5° < CRP < 22.5° (Fig. 3). Anti-phase mode was taken to be between −80° < CRP < −157.5° and 157.5° < CRP < 180°. Beyond this step, a coordination mode of intermediate phase was also taken into account.

**Statistics.** The normality of the distribution (Ryan Joiner test) and the variance homogeneity (Bartlett test) were checked before using parametric statistics. Two ways ANOVA (fixed factor: skill level; random factor: subject) compared the upper limb angle, the lower limb angle and the upper / lower limb coordination between the two groups. All tests were conducted with Minitab 15.1.0.0 ® software (Minitab Inc., Paris, France, 2006) with a conventional significance level of $p < 0.05$.

RESEARCH RESULTS

Both groups showed an upper/lower limb coordination which is in average in in-phase mode (mean CRP = −2°). However, the elite climbers further varied their coordination during an ascent (standard deviation of CRP = 45.1°) compared to the beginners (standard deviation of CRP = 40.9°) ($p < 0.05$). The beginners spent more time with upper / lower limb coordination in in-phase mode, and less time in out-of-phase mode (for the class −77.6 to −90° and 77.6 to 90°) (Fig. 4).

On average, during the whole period of climbing, both groups of climbers had their two ice tools horizontally (15.4° for beginners and 12.4° for elite climbers) and their crampons in horizontal position (24.1° for beginners and 19.8° for elite climbers). However, elite climbers further varied their upper limb angular position (standard deviation of ice tools angle = 50.2° *vs.* 31.1° for beginners) and their crampons angular position

Figure 4. **Continuous Relative Phase (CRP) spent in in-phase and out-of-phase mode**
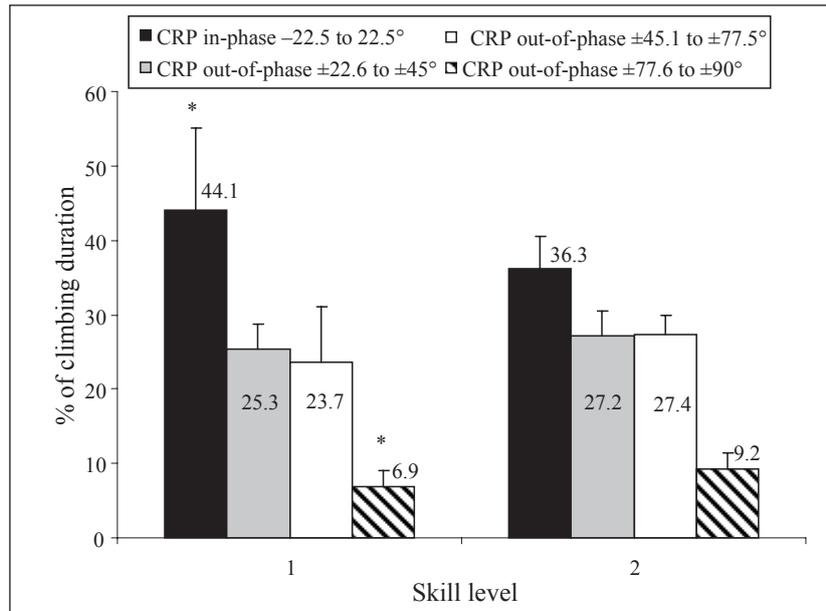
Note. Group 1 – beginners; group 2 – elite climbers; * – significant differences compared to group 2 at p < 0.05.

Figure 5. **Time spent with the ice tools in different angular positions**
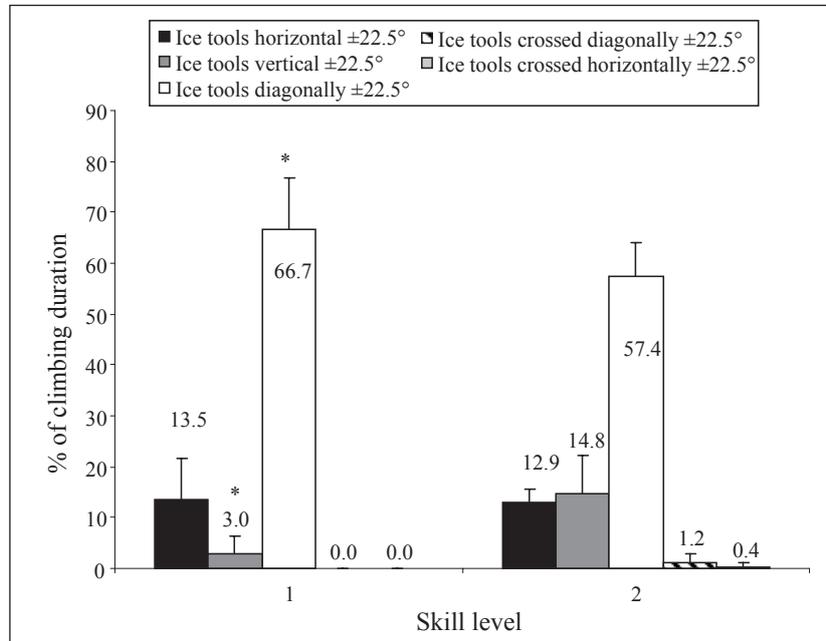
Note. Group 1 – beginners; group 2 – elite climbers; * – significant differences compared to group 2 at p < 0.05.

Figure 6. **Time spent with the crampons in different angular positions**
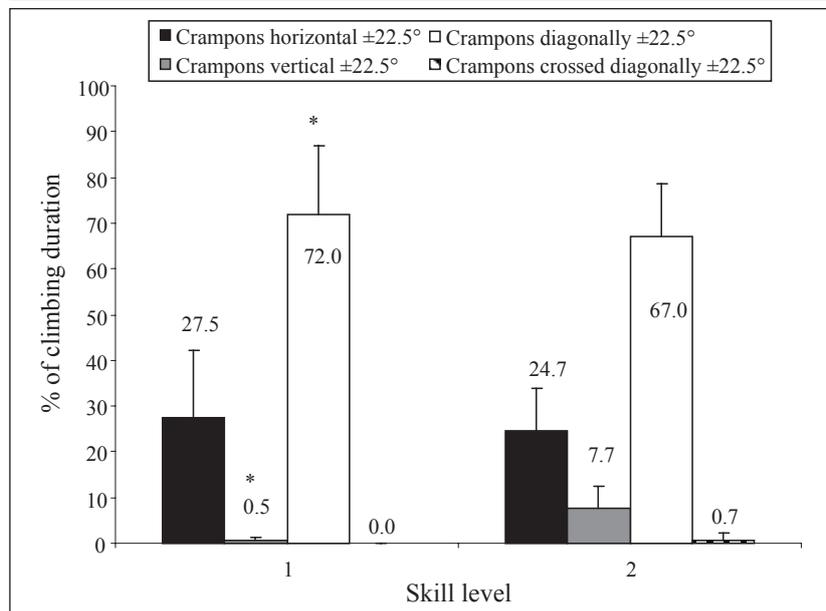
Note. Group 1 – beginners; group 2 – elite climbers; * – significant differences compared to group 2 at p < 0.05.
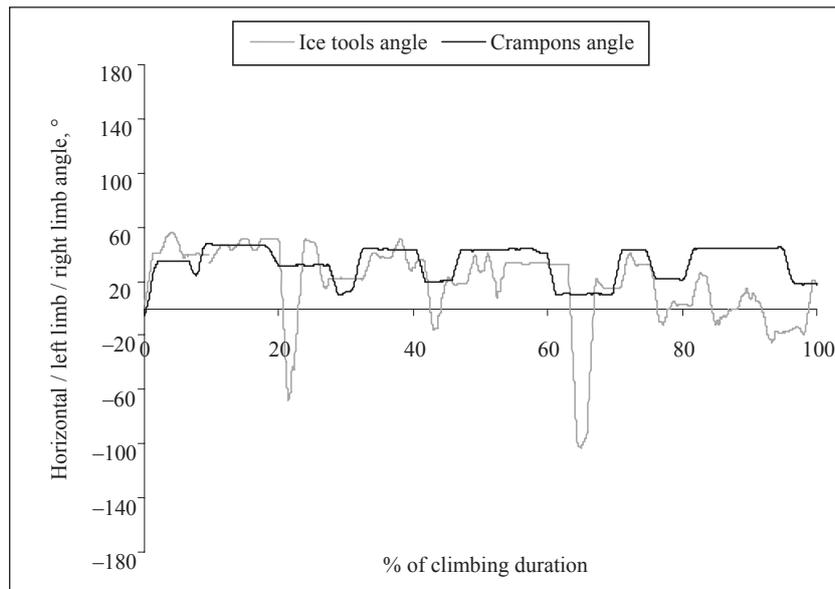
Figure 7. **Example of angle-time curve for ice tools and crampons angle of a beginner**
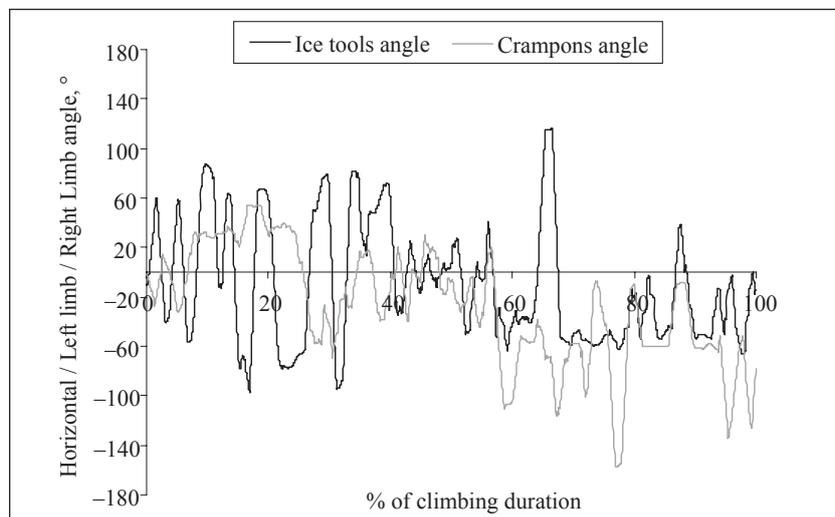

Figure 8. **Example of angle-time curve for ice tools and crampons angle of an elite climber**

(standard deviation of crampons angle = 38.7° *vs.* 25.0° for beginners) (p < 0.05). Beginners spent more time with their two ice tools and their two crampons diagonally and less time with their ice tools and their crampons in a vertical position than elite climbers (p < 0.05) (Figs. 5 and 6). Moreover, unlike the elite climbers, beginners never crossed their ice tools and their crampons (Figs. 5 and 6), which explained their lower variety of angular position and their upper/lower limb coordination mainly in in-phase mode.

DISCUSSION

Beginners mostly used one coordination mode (in-phase) and low variety in their upper / lower limb coordination. These results are in accordance with previous studies (Vereijken et al., 1992; Temprado et al., 1997; Seifert et al., 2010) highlighting that the beginners frozen their degrees of freedom. Freezing the degrees of freedom comes from the static "X" body position with the arms and legs extended (i. e. in-phase mode of coordination). In fact, their behaviour looked like climbing up a ladder, with an alternation of in-phase mode (i. e. body in "X" position) and of out-of-phase mode, the latter corresponding to (i) one arm swinging an ice tool while the two legs were extended or (ii) kicking in the crampons or pushing up with one foot while the arms pulled with the two ice tools at the same level. The dominance of the in-phase mode was due to the long time the beginners spent in a static position to find their way or to swing their ice tool and to kick their crampons in order to create deep holes. This behaviour reminds those observed in studies about rock climbing showing that if the climbers use a smaller number of holds to move along the artificial climbing wall, they have to be quick enough to maintain equilibrium;

and vice versa, if the number of holds is equal or greater than three, it means that they climb slowly because their equilibrium is always under control (Boschker et al., 2002; Sibella et al., 2007).

Figure 7 shows good example of in-phase mode of upper/lower limb coordination, corresponding to a beginner who often kept his ice tools and crampons angle in the same position (showing plateau in the angle-time curve).

Conversely, the elite ice climbers used a variety of motor solutions, notably for one ice tool swinging in a vertical position in comparison to the second ice tool, they move up their crampons two or three times (Fig. 8). They avoided the static "X" body position and too much ice tool swinging and crampon kicking, which may cause fatigue.

CONCLUSIONS AND PERSPECTIVES

The elite climbers hooked their ice tools into existing holes and put their crampons in the holes made by the ice tools, showing that the holes corresponded to affordances determining the behaviour of the elite climbers. Indeed, trying to interact as well as they can with the environment (i.e. the ice fall shape), the elite climbers sometimes crossed the right and left limbs to use existing holes in the ice fall. M. S. J. Boschker et al. (2002) have previously showed that expert rock climbers recalled more information and they focused on the functional aspects of a climbing wall, whereas they neglected its structural features. Conversely, the beginners did not recall such information and they reported almost exclusively the structural features of the holds (Boschker et al., 2002). It confirmed that hold in rock climbing and hole in ice climbing looked like affordances for expert whereas it induced less motor adaptation in beginners.

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SKIRTINGO MEISTRIŠKUMO LEDO ALPINISTŲ RANKŲ IR KOJŲ TARPUSAVIO KOORDINACIJOS KAITUMAS

Ludovic Seifert[1], Leo Wattebled[1], Maxime L'Hermette[1], Romain Herault[2]
Ruano universitetas[1], Ruanas, Prancūzija
Taikomųjų mokslų nacionalinis institutas[2], Ruanas, Prancūzija

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Alpinistai kopdami ledu patys pasidaro kilimo takus (skyles) batų kabliais ir ledkirčiais. Sušalusio krioklo aplinkoje tenka derinti rankų ir kojų darbą be iš anksto numatytų koordinacijos modelių.

Tikslas: išanalizuoti skirtingo meistriškumo ledo alpinistų rankų ir kojų koordinaciją stebint, kaip kopiantysis panaudoja aplinkos kliūtis (sušalusio krioklo ledo formas) judesiams atlikti.

Metodai. Šeši didelio meistriškumo ledo alpinistai ir penki pradedantieji kopė į 30 m aukščio sušalusį krioklį (atitinkamai 5 / 5+ ir 4 balų). Priekinė vaizdo kamera įrašinėjo rankų ir kojų darbą per pirmuosius 15 kilimo metrus. Buvo siekiama išanalizuoti rankų ir kojų bei jų tarpusavio koordinaciją.

Rezultatai. Fazinis rankų ir kojų koordinacijos režimas buvo pagrindinis atraktorius abiejose grupėse. Didelio meistriškumo ledo alpinistai, palyginti su pradedančiaisiais, parodė didesnį savo elgsenos kaitumą ieškodami įvairesnių rankų ir kojų judesių kampų (ypač vertikalių ir sukryžiuotų padėčių) ir judėjimo būdų (mojuodami ledkirčiais ir smeigdami kablius į ledą).

Aptarimas ir išvados. Galima teigti, kad skylės lede ir sušalusio krioklio ledo forma daro įtaką didelio meistriškumo ledo alpinistų rankų ir kojų koordinacijos kaitai, o pradedantieji alpinistai labiau naudojasi pastoviais judėjimo įgūdžiais pausiausvyrai išlaikyti.

Raktažodžiai: rankų ir kojų koordinacija, aplinkos kliūtys, judėjimo būdai.

Corresponding author **Ludovic Seifert**
Université de Rouen
Faculté des Sciences du Sport
CETAPS
Boulevard Siegfried
76821 Mont-Saint-Aignan Cedex
France
Tel (33)-2 32 10 77 84
E-mail ludovic.seifert@univ-rouen.fr

DEPENDENCE OF MUSCLE TORQUE OF ANKLE PLANTAR AND DORSAL FLEXORS ON DIFFERENT ANKLE ANGLES

Rima Solianik[1], Vaida Aleknavičiūtė[1,2], Zita Andrijauskaitė[1], Algimantas Putramentas[3], Gintarė Dargevičiūtė[1], Dovilė Parulytė[1], Albertas Skurvydas[1]
Lithuanian Academy of Physical Education[1], Kaunas, Lithuania
Šiauliai State College[2], Šiauliai, Lithuania
Vytautas Magnus University[3], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. There is much research information about the relationship between the knee joint angle and the quadriceps muscle torque (Mohamed et al., 2002), but still we lack evidence about the relationship between ankle angle and calf muscle torque.

Research aim. The purpose of this research was to establish the dependence of maximal voluntary contraction (MVC) and electrical stimulation (ES)-evoked torque and calf muscle electrical activity (EMG) on different ankle plantar and dorsal flexion angles. We hypothesized that the calf muscle MVC and ES-evoked torque as well as muscle EMG amplitude would increase with increasing muscle length (i. . increasing ankle angle).

Research methods. The subjects in the research were ten non-trained men. Calf plantar and dorsal flexors muscle ES and MVC torque were tested at eight different ankle angles (-25°; -15°; -5°; 0°; 15°; 25°; 35°; 45°) which were chosen in randomized sequence. The tibialis anterior, soleus, gastrocnemius lateralis and medialis muscle EMG were measured during muscle MVC.

Research results. The results showed that the highest ES-evoked and MVC developed torque of plantar flexion muscles was at -25° ankle angle (149.1 ± 31.6 N·m and 207.8 ± 38.1 N·m, respectively), while the highest dorsal flexion MVC muscle torque was at 25° ankle angle (47.2 ± 8.1 N·m). However, dorsal flexion muscle MVC torque increased with the muscle length only until 25° ankle angle.

Discussion and conclusions. Plantar flexion muscle electrical stimulation evoked and plantar / dorsal flexion muscle maximal voluntary contraction torques are highest at that ankle angle where muscle length is the longest.

Keywords: maximal voluntary contraction, electrical stimulation, EMG.

INTRODUCTION

In scientific literature, biomechanics of lower limb musculoskeletal system has been widely considered. Data on the biomechanical peculiarities of lower extremities can be used not only for improving performance in sports, but also for injury prevention and rehabilitation. Muscular torque is the result of the applied force and the lever arm multiplication (Arnold et al., 2009), which magnitude depends on muscle length (i. e. angular position), contraction mode, angular velocity (Babault et al., 2003; Skurvydas et al., 2008) and central nervous system activation (Desbrosses et al., 2006).

It has been found that changing the joint angle the length of muscle changes as well, which affects the maximal muscle torque (Thomas et al., 1987; Babault et al., 2003; Skurvydas et al., 2008; Arnold et al., 2009). O. Mohamed and co-authors

(2002) performed hamstring muscle length and force dependence research and direct correlation was found between muscle length and maximal voluntary muscle torque.

It is well known that the electrical stimulation (ES)-induced muscle force depends on the amount of stimulation frequency and voltage. ES-induced thigh muscle torques as well as maximal voluntary contraction (MVC) torque depend on muscle length. When thigh muscles are at longest length, they evoke higher torque (De Ruiter et al., 2004). However, Creswell and co-authors (1995) found an opposite muscle length and ES-evoked calf muscle torque dependence. They established that, when the knee angle flexion increased from 60° to 180°, the ES-induced muscle torque of the gastrocnemius decreased. Thus, the maximum gastrocnemius muscle length did not evoke maximal muscle torque (Creswell et al., 1995). The tibialis anterior muscle torque evoked by ES in a different joint angle has not been widely studied.

Muscle electrical activity (EMG) reflects the muscle motor unit potential (Arampatzis et al., 2006). When high muscle forces are at work, they include a large amount of motor units (Thomas et al., 1987). References provide contradictory muscle activity data at different joint angles (Babault et al., 2003). Some scientists state that the activity of a muscle does not change performing an isometric movement (Thomas et al., 1987; Gandevia, McKenzie, 1988; Bigland-Ritchie et al., 1992), others claim that the activity changes at different angles (Marsh et al., 1981; Cresswell et al., 1995; Kasprisin, Grabiner, 2000; Arampatzis et al., 2006). Therefore, it is important to assess the muscle EMG and the muscle length dependence on isometric muscle work.

There is a lack of information about the relationship between muscle lengths at different ankle angles and electrically as well as voluntarily evoked calf muscle torque.

Therefore the purpose of this study was to evaluate ankle plantar and dorsal flexors muscle torque dependence on the different ankle angles.

RESEARCH METHODS

Subjects. Ten healthy non-trained male subjects volunteered to participate in the study (height 181.8 ± 4.2 cm; body mass 80.4 ± 5.3 kg; age 24.5 ± 1.5 years; means ± SE). All the experimental procedures were performed in accordance with the Declaration of Helsinki and all the subjects gave written informed consents to participate in the study.

Protocol. The details of the experiment were explained to the participants before testing. The participants were checked if they could tolerate ES at different ankle angles with the stimulation voltage from 30 to 120 V, 24 hours before the experiment (Fig. 1). On the day of the experiment the subjects performed a 5-min warm-up at 80–100 r.p.m. with a 60–100 W resistance on an Ergo–Fit ergometer. The experiment started from the calf muscles ES at different ankle angles. After the ES procedure (5–10 min), the subjects performed dorsal and plantar flexion MVC at eight different ankle angles (Fig. 1). At each angle the subjects were allowed to develop two trials of 5 seconds MVC with a 30 s pause between each trial and 60 s pause between the angles. Visual feedback of torque output was provided to the subjects on a computer screen during each trial. EMG was measured during MVC testing.

Measurement of electrical stimulation-evoked torque. A high-voltage stimulator (MG 440, Medicor, Budapest, Hungary) was used to deliver electrical stimuli to the muscles performing plantar flexion and dorsal flexion through skin surface electrodes. Two stimulation electrodes (4 × 4 cm) were placed on the proximal and distal part of the anterior tibialis muscle. Other two electrodes were
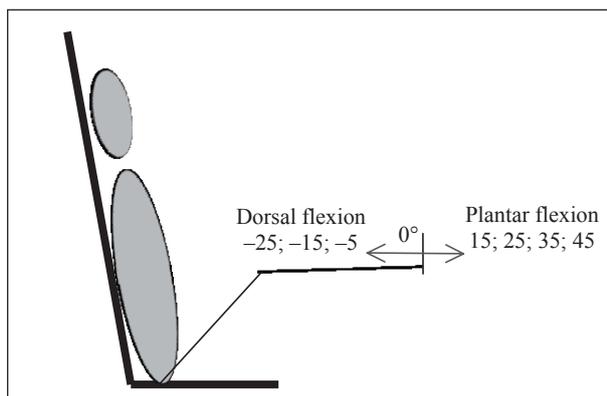

Figure 1. **Testing ankle joint position during electrical stimulation-evoked and maximal voluntary contraction torque testing**

placed on the proximal part of the gastrocnemius (electrode size, 4 × 4 cm) and the distal part of soleus and gastrocnemius muscles (electrode size, 7.5 × 11.5 cm). Firstly, we measured the torque of muscles performing dorsal flexion and then plantar flexion. We evoked the contractile force of muscles by 1-s train of electrical stimuli at 100 Hz and voltage of 150 V (Skurvydas et al., 2008) at eight (Fig. 1) ankle angles with a 60 s pause between stimulations. The measurements were performed in a randomized sequence.

Measurement of maximal voluntary contraction torque. Isometric muscle torque testing was performed using the Biodex System 3 (*Biodex Medical System,* Shirley, NY). This device, which was equipped with a footplate that was fixed to the rotational axis of the motor, recorded the torque generated by the dorsiflexor muscles under static conditions for different ankle joint angles. The subject was secured on an adjustable chair in a slightly reclined position and strapped at the hip and chest. The foot was strapped to the plate so that the axis of rotation of the ankle joint was aligned with the shaft of the motor. In neutral position, the plate was inclined at an angle of 45° relative to the floor. The position of the subject was adjusted to obtain a 90° angle for the ankle (neutral position or 0°). The foot was held in place by a heel block and was tightly attached to the plate by two straps. One strap was placed around the foot, 1–2 cm proximal to the metatarsophalangeal joint of the toe, and the second strap was placed around the foot, just below the ankle joint. To correct the effect of gravity on the measured joint movements, the passive mass of the foot was measured in the dynamometer at an ankle joint angle of 15°. All the subjects were tested without shoes. The dominating leg was identified by asking each participant which leg they preferred to kick a ball as far as possible (Ford et al., 2003).

**Measurements of muscle electrical activity.** EMG signals were recorded in the ankle dorsal flexion muscle (anterior tibialis muscle) and the ankle plantar flexion muscles (soleus, gastrocnemius lateralis and medialis mucles) using Biometrics Ltd electromyography (UK). After the careful preparation of the skin (shaving, abrasion and cleaning with alcohol), electrodes (Ag / AgCl) were placed following the recommendations of SENIAM for the location of sensors on muscles. Before starting the experiment we performed a manual test of EMG electrodes to be sure that they were placed correctly (Hermes et al., 1999). All EMG signals were synchronously recorded with MVC measurements.

Mathematical statistics. The research data were processed using Microsoft Excel 2007 program mathematical statistical analysis. The data are reported as group mean values ± standard deviations (SD). Changes between 0 and –25, –15, –5, 15, 25, 35, 45° angles were evaluated using Student's (t) test ($p < 0.05$ level of significance).

RESEARCH RESULTS

The highest ES-evoked torque of plantar flexion muscles (Fig. 2) was developed at –25° angle (149.1 ± 31.6 N·m). The data between the angles showed that at –25; –15; –5° angles the muscle torque was higher ($p < 0.05$), and at 25; 35; 45° angles the muscle torque was lower ($p < 0.05$) compared to 0° angle torque.

The highest MVC muscle torque of foot plantar flexion (Fig. 2) was also developed at the –25° angle (207.8 ± 38.1 N·m). Comparing the data between the angles we established that at the –25; –15 angles the muscle torque was higher ($p < 0.05$), and at the 15; 25; 35; 45° angles the muscle torque was lower ($p < 0.05$) than the torque at the 0° angle (Fig. 2).

Figure 2. **Maximal voluntary contraction (MVC) and electrical stimulation (ES)-evoked muscle torques during plantar flexion at different angles**
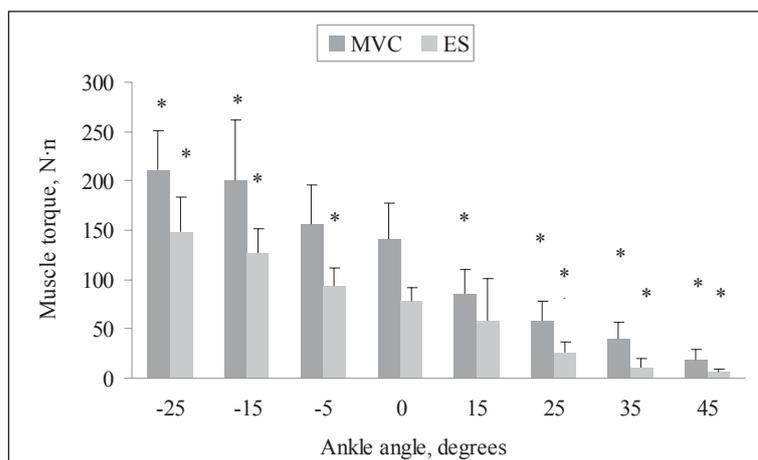
Note. * – $p < 0.05$, the difference between 0° and –25; –15; –5; 15; 25; 35; 45° angles.
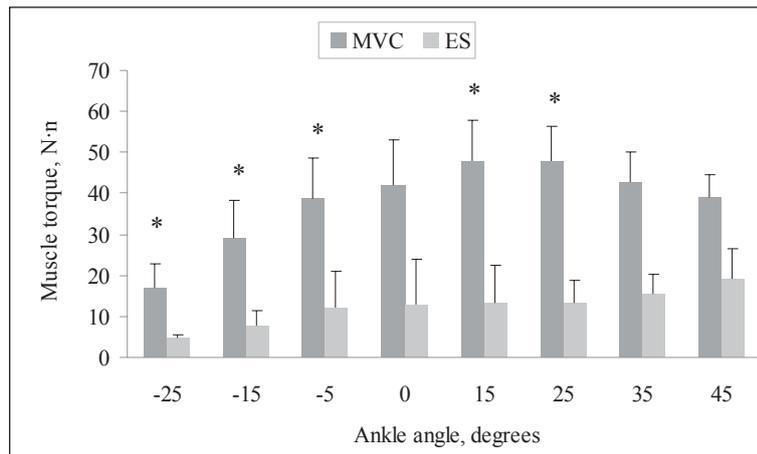
Figure 3. **Maximal voluntary contraction (MVC) and electrical stimulation (ES) – evoked muscle torques during ankle dorsal flexion at different angles**

**Note.** * – $p < 0.05$, the difference between 0° and –25; –15; –5; 15; 25; 35; 45° angles.
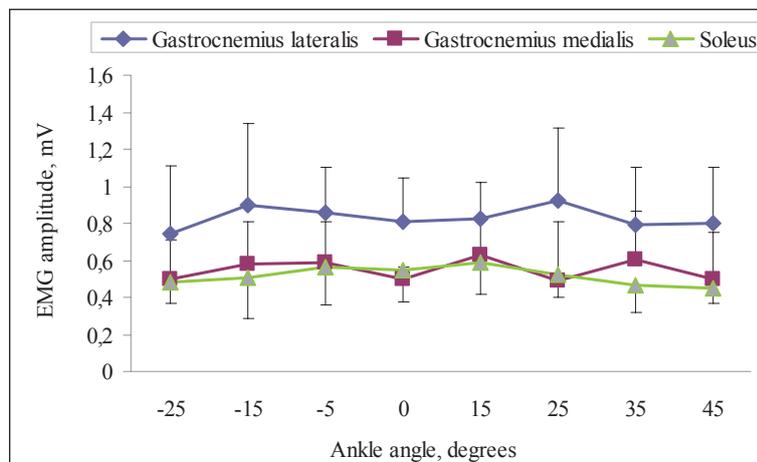
Figure 4. **Maximal soleus, gastrocnemius medialis and lateralis muscle electrical activity (EMG) amplitude during foot plantar flexion at different ankle angles**
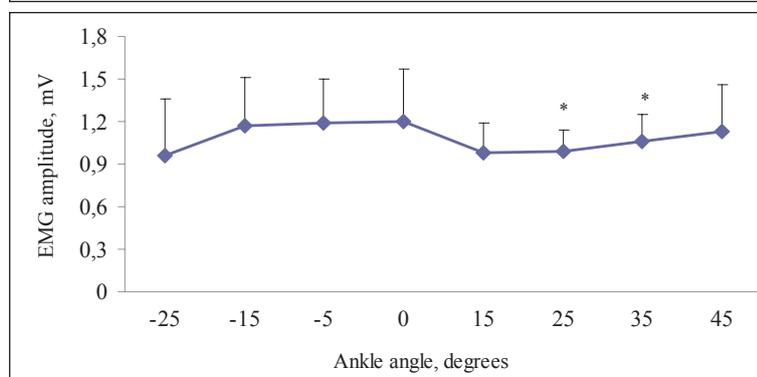

Figure 5. **Maximal tibialis anterior muscle electrical activity (EMG) amplitude during foot dorsal flexion at different ankle angles**

Note. * – $p < 0.05$, the difference between the 0° and the –25; –15; –5; 15; 25; 35; 45° angles.

Unlike the ES-evoked torque of plantar flexion muscles, dorsal flexion muscle did not show any statistical significant changes compared to 0° angle (Fig. 3).

The highest dorsal flexion MVC muscle torque (Fig. 3) was developed at the 25° angle (47.2 ± 8.1 N·m). The comparison of the data between the angles showed that at the –25; –15; –5° angles the muscle torque was lower ($p < 0.05$), and at the 15°; 25° angles the muscle torque was higher ($p < 0.05$) than the torque at the 0° ankle angle.

We did not establish any statistically significant differences of the EMG amplitude of soleus, gastrocnemius lateralis and medialis muscles at different ankle angles (Fig. 4). However the tibialis anterior muscles EMG amplitudes data (Fig. 5) at

25 and 35° ankle angles were lower ($p < 0.05$) compared to 0° angle.

DISCUSSION

We have established that in presence of the maximum muscle length, the highest plantar flexion ES-evoked and plantar / dorsal flexion MVC muscle torque is developed. Though there have not been established any ES-evoked dorsal flexion muscle torque differences at different ankle angles, we observed a tendency that, when the muscle length increased, the muscle torque increased as well. No plantar flexion muscle EMG amplitude dependencies on different ankle angles have been estimated, either. However there is evidence about

dorsal flexion muscle EMG amplitude differences at 25 and 35 ° ankle angles.

In scientific research dealing with ankle angle and muscle torque dependence, MVC is usually explored in the amplitude of 30° of a foot plantar flexion and –20° of a foot dorsal flexion (Sale et al., 1982; Anderson et al., 2007; Arnold et al., 2009). In our research, the MVC torque of calf muscles was measured at the maximal ankle joint amplitude (i. e. 45° plantar flexion and –25° dorsal flexion) in order to investigate the muscle capabilities to develop muscle force at wider range of amplitudes. D. E. Anderson and co-authors (2007) established that the highest muscle torques performing dorsal flexion of a foot was at the angles of –15° and –20°, respectively – 156 N·m and 170 N·m. In our research we established that the highest MVC plantar flexion muscle torque was at the –25° angle.

It has been estimated that dorsal flexion muscle (tibialis anterior) is thin; therefore the developed muscle torque during a movement does not change significantly at different angles (Arnold et al., 2009). E. M. Arnold and co-authors (2009) performed a study where they established that the highest MVC torque was at the 7° angle. In our research we established that the highest MVC torque was developed at the 25° angle. Interestingly, at the 35 and 45° ankle angles the length of the muscle increased, but the MVC torque decreased. We suppose that the 25° ankle angle coincides with the optimal ankle angle.

We estimated that ES-evoked plantar flexion muscle torque was the highest at the –25° angle, and the lowest – at the 45° angle. We established that the plantar flexion muscle ES-evoked torque directly depended on the ankle angles. At the angle where the length of the muscle was the biggest, we observed the highest plantar flexion muscle ES-evoked torque. However, we did not establish significant differences in the dorsal flexion muscle torque at different angles, but we noticed that

when the length of a muscle increased the torque increased, too.

Some authors provide contradictory results of the electrical activity of muscles. It has been known that muscle EMG depends on muscle length (Farina, 2006). However, A. G. Cresswell et al. (1995) performed plantar flexion EMG muscle studies at different muscle lengths and observed that the activity of a soleus muscle did not change, when the length changed. Our research results confirmed that not only soleus muscle but also gastrocnemius muscles did not depend on different ankle angles.

E. Marsh et al. (1981) established that the tibialis anterior muscle activity was lower at the longest muscle length. In our research we also observed the tendency that when the tibialis anterior muscle was at longer length the EMG amplitude was lower, and vice versa, when the muscle was shorter the EMG amplitude was higher. However, the significant changes were observed only at 25 and 35° ankle angles.

Summarizing the results of the research we may state that the value of the calf muscle torque depends on the muscle length and EMG amplitude was independent of ankle angle, except for tibialis anterior EMG amplitude which was significantly lower at 25 and 35° ankle angles.

CONCLUSIONS AND PERSPECTIVES

Plantar flexion muscle electrical stimulation evoked and plantar / dorsal flexion muscle maximal voluntary contraction torques are highest at that ankle angle where muscle length is the longest. It was established that the torque of the dorsal flexion electrical stimulation evoked muscle torque was independent of different ankle angles. Furthermore, electrical activity of plantar and dorsal flexion muscles at different ankle angles was independent of muscle length, except for tibialis anterior EMG amplitude at 25 and 35° ankle angles.

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PĖDOS LENKIAMŲJŲ IR TIESIAMŲJŲ RAUMENŲ JĖGOS MOMENTO IR PĖDOS SĄNARIO KAMPO PRIKLAUSOMYBĖ

Rima Solianik[1, 2], Vaida Aleknavičiūtė[1, 2], Zita Andrijauskaitė[1], Algimantas Putramentas[3], Gintarė Dargevičiūtė[1], Dovilė Parulytė[1], Albertas Skurvydas[1]
Lietuvos kūno kultūros akademija[1], Kaunas, Lietuva
Šiaulių kolegija[2], Šiauliai, Lietuva
Vytauto Didžiojo universitetas[3], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Moksliniuose straipsniuose gausu informacijos apie šlaunies keturgalvio raumens jėgos momento ir kelio sąnario kampo priklausomybę (Mohamed et al., 2002). Tačiau nėra plačiai tyrinėta blauzdos raumenų jėgos momento ir pėdos sąnario kampo priklausomybė.

Tikslas: nustatyti pėdos lenkiamųjų, tiesiamųjų raumenų maksimaliosios valingos jėgos (MVJ) ir elektros stimuliacijos (ES) sukelto jėgos momento bei raumenų elektrinio aktyvumo (EMG) priklausomybę nuo pėdos sąnario kampo. Buvo iškelta hipotezė, kad pėdos lenkiamųjų ir tiesiamųjų raumenų MVJ, ES sužadintas jėgos momentas bei raumenų EMG amplitudė didės, kuomet raumuo bus ilgas (t. y. didės kampas).

Metodai. Buvo tiriama dešimt nesportuojančių vyrų. Tyrimo metu pėdos lenkiamųjų ir tiesiamųjų raumenų jėgos momentas tirtas atsitiktine tvarka parinkus aštuonis skirtingus (-25°; -15°; -5°; 0°; 15°; 25°; 35°; 45°) pėdos sąnario kampus. Tiriamųjų priekinio blauzdos, plekšninio, vidinio ir šoninio dvilypio raumenų EMG buvo registruota izometrinio MVJ momentu.

Rezultatai. Nustatyta, kad pėdos lenkiamųjų raumenų ES sukeltas ir MVJ išugdytas didžiausias jėgos momentas buvo tada, kai pėda sulenkta $-25°$ kampu ($149,1 \pm 31,6$ ir $207,8 \pm 38,1$ N·m). O pėdos tiesiamųjų raumenų didžiausias MVJ momentas – kai pėda sulenkta $25°$ kampu ($47,2 \pm 8,1$ N·m).

Aptarimas ir išvados. Pėdos tiesiamojo priekinio blauzdos raumens ES sukeltos jėgos momentas nepriklauso nuo pėdos sąnario kampo.

Raktažodžiai: maksimalioji valinga jėga, elektrostimuliacija, EMG.

Corresponding author **Rima Solianik**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lietuva
Tel +370 606 95214
E-mail r.solianik@lkka.lt

DANCING WITH COMPLEXITY: OBSERVATION OF EMERGENT PATTERNS IN DANCE IMPROVISATION

Carlota Torrents[1], Marta Castañer[1], Maria Teresa Anguera [2]
University of Lleida[1], Lleida, Spain
University of Barcelona[2], Barselona, Spain

ABSTRACT

Research background and hypothesis. Dance is presented as a context to study emergent and nonlinear behaviour. Manipulating the task constraints and the agent/environment and agent / agent interactions is used to enhance the divergent production of motor responses, which is studied using observational methodology.

Research aim. Our aim was to test an observation instrument capable of detecting synchronisations and spontaneous interactions in a group of dancers.

Research methods. Seven dancers improvised during four five-minute trials involving four different constraints (Free movement; Free movement, but previously they had spent one minute breathing at the same time; Only walking and moving one's arms; Free movement, but if one dancer stops, they must all stop at the same time). The recording instrument was the MatchVision Studio Software, and the data were analysed using THEME v.5 software (Magnusson, 1996, 2000).

Research results. The results, as reflected by the T-patterns detected (twenty in Trial 1, eleven in Trial 2, twenty-one in Trial 3 and eight in Trial 4) and the frequency of the recorded events, show the following with these dancers: (1) the observational instrument developed has enabled us to analyse synchronisation and interaction of dancers, as well as to detect repeated sequences of events; (2) the most frequent event is the interaction in pairs using physical contact; (3) very strong constraints limit the emergence of varied patterns; and (4) a previous synchronisation of breathing enhanced the group's synchronisation and the use of physical contact between members while dancing.

Discussion and conclusions. The observational instrument developed has enabled us to analyze the synchronization and interaction of dancers, as well as to detect repeated sequences of events.

Keywords: observational methodology, synchronization, constraints, nonlinear behaviour.

INTRODUCTION

The uniqueness of dance arises out of the juxtaposition between human motion and art. Dance as an "art object" has a dynamic dimension (motion) not present in other art forms, while dance as physical activity has an emotional dimension which requires consideration not only of technical but also of creative features of the dancer's movement. The evolution of dance has been determined by the need to experiment and create new ways of moving, as well as by the exploration of new forms of human movement that are not based on the need to win or do better than an opponent. During the last century, choreographers and dancers, as artists,

were attracted by new trends in contemporary art and sought for a more natural and free way of dancing. Science also influenced dance, and systemic and complex systems approaches have been present in the research process of different artists. Indeterminacy, improvisation, chaos and breaking with cause-effect relationships were key concepts in a number of important dance works, such as those of Cunningham, many years before the complex systems approach was applied in motor control and learning. Principles such as equifinality, (neg)entropy and morphogenesis were all considered in an attempt to understand human motion in dance (Castañer, Camerino, 2003). Dance paid attention to complex phenomena many years before sport did, and this makes dance an interesting context in which nonlinear sport scientists can study emergent and nonlinear behaviour. Furthermore, dance needs to be based on creativity. At all events, we cannot rely on stereotypes, and following a single map –as if it were an algorithm – prevents us from discovering other routes in a heuristic way.

Dance improvisation is an innovative dance process that takes the dancer beyond habituated patterns of movement and modes of comportment into a realm of unknown possibilities where new ways of moving can be discovered and experienced (Clark-Replay, 1999). This process is mainly based on creative games, playing with one's own movement, rhythm, space, dancers and equipment. All of these constitute constraints on the emergence of coordinated behaviour between dancers or on the discovery of new ways of dancing.

In line with certain trends in nonlinear pedagogy (Chow et al., 2006), methods of teaching contemporary dance and improvisation are focused on exploration, play and discovery. Traditionally, teachers of dance improvisation have used a constraints-led methodology, manipulating the task constraints and the agent/environment and agent/ agent interactions. Studies of these interactions have shown the influence of dancing with a partner in terms of enhancing the divergent production of motor responses (Torrents et al., 2010).

The proposal here is to study complex behaviour in dance by means of observational methodology. The latter is a scientific procedure that can reveal the occurrence of perceptible behaviours, allowing them to be formally recorded and quantified. It also enables the analysis of relationships between these behaviours, such as sequentiality, association and covariation.

In all settings one finds a range of behaviours which form a pyramidal structure. Starting from the top of the pyramid, everyday dance in a natural context can be broken down into different levels (such as leisure, motor behaviour, etc.), revealing a tree structure with a hierarchical subdivision of situations in which behaviours that tend towards molarity interact with their natural contexts (Anguera et al., 1999). Towards the base of the pyramid the perceptible behaviours become increasingly molecular.

Observational methodology can be used here due to the habitual nature of human behaviour and the fact that the context is a naturalistic one. Indeed, the flexibility and rigour of this methodology makes it fully consistent with the characteristics of our research on body movement and dance (Castañer et al., 2009 b). More specifically, our research approach is based on sequential and real-time patterns, known as T-patterns, which, in conjunction with detection algorithms, can describe and detect behavioural structure in terms of repeated patterns (Magnusson, 2000). It has been shown that such patterns, while common in behaviour, are typically invisible to observers, even when aided by standard statistical and behaviour analysis methods.

In order to improve the scenarios to be managed in body movement and dance practices it is important to identify the essential constraints of specific motor skills, space (such us axes, planes and volumes or the use of the total space), time, and interaction between partners. Our intention is not to explore unobservable aspects such as feelings or emotions that are always implied in dance but, rather, to study what is directly observable from an objective point of view.

We have previously applied observational methodology to study the influence of different instructions and dancing with partners as a way of enhancing motor creativity in creative dance and contact improvisation, as well as for studying the sequence of motor actions in folklore dance (Castañer et al., 2009 a, 2009 b; Torrents et al., 2010). However, this research was focused on the individual responses of dancers and creativity was studied by paying attention to the variety of motor skills performed according to the teacher's instructions or the partner of the dance duet. The category system used for the analysis (OSMOS– Castañer et al., 2009 b) classified motor skills and the variations that dancers could use while dancing. However, in order to study further the

way in which patterns emerge in contemporary dance we were interested in creating an observation instrument capable of detecting synchronisations and spontaneous interactions within a group of dancers. In this paper we test the instrument by studying the effect of constraints-led proposals for improvising and composing, especially as regards enhancing interactions and spontaneous synchronisation in a performance or in training sessions. Improvised dance was observed using different instructions in order to analyse how these may affect attention to the group and the interaction among its members.

RESEARCH METHODS

Seven students (five females and two males; mean age 21.5 ± 2.5 years) of Physical Activity and Sport Sciences with more than one year of experience dancing in a contemporary dance group participated voluntarily in this study. Their task was to improvise dancing in a space of (8 × 8) m during four five-minute trials in which they received no specific instruction regarding how to interact, synchronise or *listen* (in dance terminology, being aware of the other dancers) within the group. Each trial was focused on different constraints:

1) Free movement, without specific instructions.
2) Free movement, but previously they had spent one minute breathing at the same time while sitting in a circle and holding hands. The synchronisation of breathing might enhance the synchronisation of the dancers' free movement afterwards.

3) Only walking and moving one's arms were allowed. Simplifying the instructions might also enhance attention to the group rather than to one's own movement.
4) Free movement, but if one dancer stops, they must all stop at the same time. This instruction forces the dancers to *listen* to the group, which might also enhance their interaction and spontaneous synchronisation.

The four trials were video recorded and video images were analysed by two expert observers using an instrument based on changing criteria (time, interaction, contact and space), each of which gives rise to a category system that is exhaustive and mutually exclusive (see Table 1). The recording instrument used was the MatchVision Studio software, an interactive video coding program, which allows effective recording of the time of occurrence of behavioural events, i.e. their beginnings and endings (see Figure 1.). Data quality was assessed by calculating the kappa coefficient (Blanco-Villaseñor, Anguera, 2000) and data were analysed using THEME v.5 software (Magnusson, 1996, 2000). The THEME software enables complex repeated temporal patterns to be detected even when a large number of unrelated events occur in between components of the patterns, which typically makes them invisible to the naked eye. The basic assumption is that the temporal structure of a complex behavioural system is largely unknown, but may involve a set of a particular type of repeated temporal patterns (T-patterns) composed of distinguishable event-types, which are coded in terms of their

Table 1. **Category system used to analyse the spontaneous interaction and synchronisation of dancers**

Criteria	Categories
Time Synchronisation of the rhythm between dancers	**Ts:** Simultaneous action. The group performs the same movement and at the same time.
	Tcn: Canon. The group performs the same movement in sequential time.
	Trs: The group synchronises the rhythm of the movement, but without performing the same movement.
	Tc: Combination of any of the three previous categories.
Group Interaction between dancers	**Gd**: Dyad. Interaction of two dancers.
	Gmg: Microgroup. Interaction of three or more dancers (fewer than seven).
	Gg: Macrogroup. Interaction of all the dancers together.
	Gs: Different dyads or different microgroups at the same time.
	Gc: Combination of any of the four previous categories.
	NG: The seven dancers do not interact.
Contact Physical contact between the groups	**C**: Physical contact is used in the group.
	Cc: Different dyads or microgroups are dancing at the same time, and some of them use physical contact while others do not.
Space Dancers interact while paying attention to spatial features	**SG**: Dancers use a geometrical form while dancing.
	St: All the space is occupied (four corners and centre).
	Sc: Combination of both the above categories.
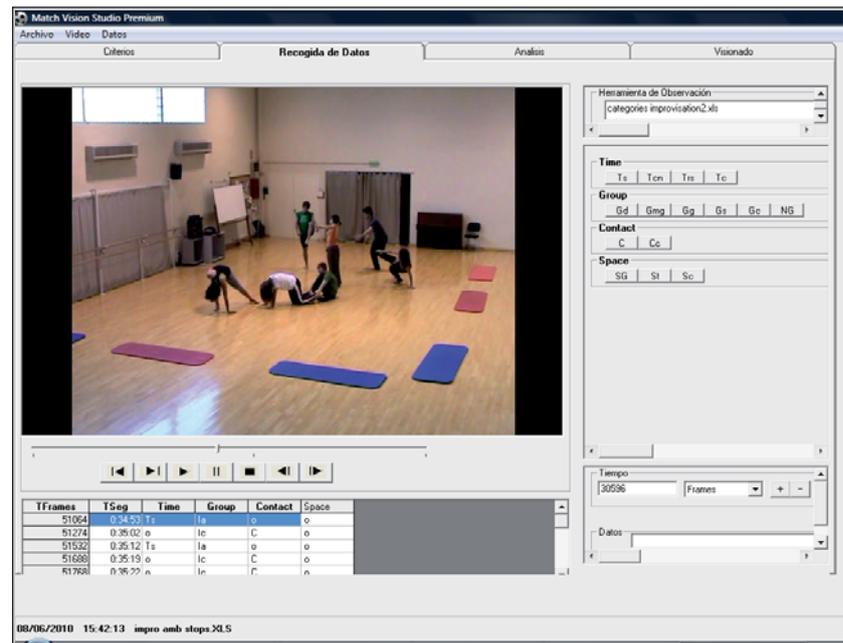
Note. Three girls are interacting (microgroup) using physical contact.

beginning and end points (such as "dancers begin by interacting in pairs using contact" or "dancers end by interacting with the whole group"). The kind of behavioural record (as a set of time-point series or occurrence time series) that results from such coding of behaviour within a particular observation period (here called T-data) constitutes the input to the T-pattern definition and detection algorithms. Essentially, if two actions, A and B, occur repeatedly within a given observation period in that order or concurrently, they are said to form a T-pattern (AB) if they are found more often than expected by chance. More complex T-patterns are gradually detected as patterns of simpler, already-detected patterns through a hierarchical bottom-up detection procedure (Magnusson, 1996, 2000).

The design for this study is N / P / M (nomothetic / point / multidimensional–Anguera et al., 2001). It is nomothetic since, as a whole, the participants can be considered at a nomothetic level due to the high level of motor interaction. It is point because we consider a single session with all the participants, and multidimensional because it combines a category system with a field format that enables us to manage four criteria including fifteen exhaustive and mutually exclusive categories. The data are Type IV (Bakeman, 1978).

RESEARCH RESULTS

Analysis of the number of occurrences of each category in the four trials (see Table 2) shows that during the second trial (where dancers breathed simultaneously before improvising) the dancers interacted more often (65 times) and with more people involved (11 in microgroups and 22 in various dyads or microgroups). In the fourth trial (with stops), there were more interactions of the whole group, but they all occurred during the stops (and therefore they were not spontaneous interactions at all). In the second trial, contact was also much more frequent (57 times) and there were more geometrical spatial forms between dancers (11). Stops produce more synchronisation of rhythms, but this is also not spontaneous. Figure 2 shows these results, excluding the synchronisations of rhythm and the interaction of the whole group in the fourth trial. Contact and interaction was much more frequent in Trial 2, while synchronisation of time was more frequent in Trial 3 (walking and moving arms). However, it is important to note that in Trial 2 there was a common rhythm to the dance between dancers, as during the five minutes they maintained a slow movement, as if they were still following the breathing rhythm.

In the second trial the dancers spent less time without interacting (7 times during 31", compared to 11 times during 1'20" of frames in Trial 1, 18 times during 1'36" in Trial 3, and 20 times during 1'36" in Trial 4).

Scores related to spatial criteria are the lowest, but it is interesting to note that in the second trial more geometrical forms were detected.

The THEME analysis, in the form of event frequency charts, shows that the most frequent

Trials / Codes	Free	Breathe	Walk	Stops
Ts	8	4	23	1
Tcn	2	5	3	1
Trs	2	0	0	21
Tc	0	0	0	0
Gd	32	21	38	29
Gmg	8	11	3	1
Gg	0	0	0	21
Gs	16	22	18	4
Gc	1	11	2	0
NG	11	7	18	20
C	36	48	32	26
Cc	7	9	6	3
SG	3	11	3	10
St	0	0	2	0
Sc	0	0	0	0
Total T	12	9	26	23
Total G	57	65	61	55
Total C	43	57	38	29
Total S	3	11	5	10

Table 2. **Number of occurrences of each category and criteria depending on the trial**

Note. All the category system codes appear vertically, and the four trials – horizontally.
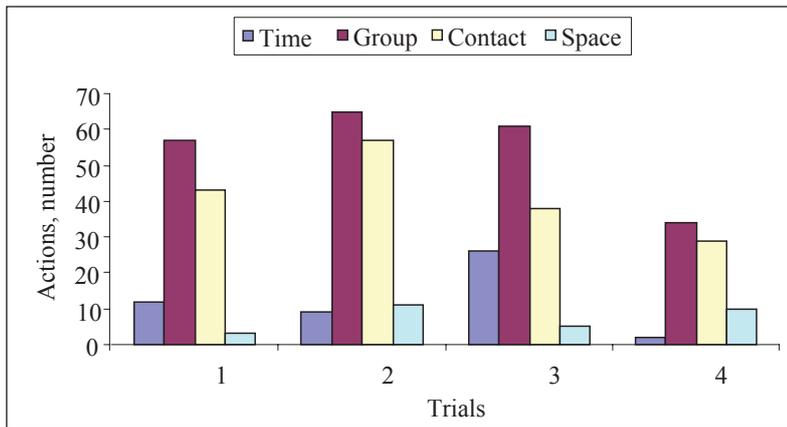
Figure 2. Frequency of occurrence of the different criteria, excluding those produced by the instruction of synchronising the stops

Note. These are total interactions without specific instructions.

Figure 3. **First T-pattern obtained for the fourth trial**
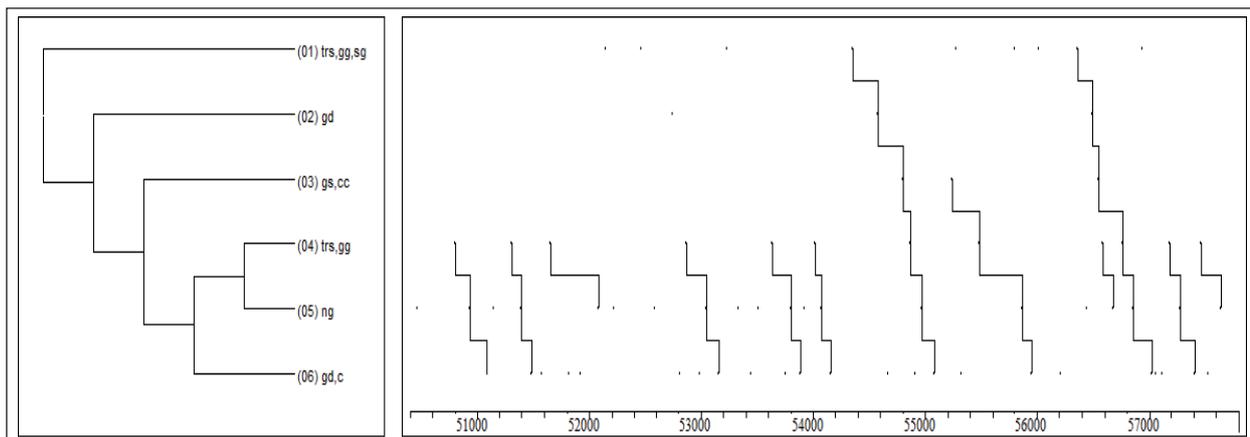
Note. There is a repeated sequence of events that begins with a stop (the whole group synchronising the rhythm) and which results in a geometrical form (trs, gg, sg). It is broken by a dyad interaction (gd), which is followed by different dyads or microgroups that interact with physical contact (gs, cc), followed in turn by another stop (trs, gg). The stop is then broken by the whole group (ng) and a dyad begins a new interaction using physical contact (gd, c).

event is the interaction in pairs using physical contact. The number of T-patterns obtained in each trial was as follows: twenty in Trial 1, eleven in Trial 2, twenty-one in Trial 3 and eight in Trial 4. In this last trial the patterns are more frequently repeated, showing that a very restrictive instruction (stops) can enhance the repetition of event sequences (see Figure 3).

DISCUSSION

The proposal to synchronise breathing during one minute prior to dancing was found to enhance the interaction between dancers, the physical contact between them and the use of a common dance rhythm. Simplifying the dance (in the third trial) enhanced the synchronisation of movement and rhythm, while the use of stops led to an impoverished performance, at least in terms of the interactions between dancers and the repetition of T-patterns. It seems that a very restrictive constraint, such as the obligation to stop if somebody else stops, limits the emergence of varied patterns. On the basis of this study alone it is not possible to affirm that the synchronisation of breathing will always have this effect, but the instrument developed has enabled us to detect this interesting phenomenon. Further research is needed in order to study the effect of synchronising breathing on other dancers or situations.

The constraints used in these trials did not enhance the attention paid by the dancers to space at all. However, as space is one of the dimensions that dancers have to control (Laban, 1991) it would be very useful to find constraints that do direct their attention to the possibility of occupying the whole available space. It would also be interesting to constrain the interaction between all the dancers, as they frequently repeat interactions in dyads by using physical contact. These results are likely due to the influence of practices associated with contact improvisation or related tasks in the dancers' experience.

CONCLUSIONS AND PERSPECTIVES

The observational instrument developed has enabled us to analyse the synchronisation and interaction of dancers, as well as to detect repeated sequences of events (T-patterns). Testing different constraints by means of this observational instrument may help to identify the most suitable instructions and conditions for enhancing the emergence of rich and varied patterns in a group of dancers, thereby fostering their self-expression and creativity.

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ŠOKIŲ SUDĖTINGUMAS: ŠOKIŲ IMPROVIZACIJOS MODELIŲ STEBĖJIMAS

Carlota Torrents[1], Marta Castañer[1], Maria Teresa Anguera[2]
Leridos universitetas[1], Lerida, Ispanija
Barselonos universitetas[2], Barselona, Ispanija

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Šokis pateikiamas kaip kontekstas, kuris sudaro galimybę tirti netiesinį elgesį. Šokio metu manipuliuojama užduoties privalomais elementais bei agento / aplinkos ir agento / agento sąveika norint išprovokuoti kuo daugiau įvairių motorinių reakcijų.

Tikslas. Naudojant stebėjimo metodą, šiuo tyrimu siekiama atskleisi šokio elementų apraiškas formaliai jas užfiksuojant ir kvantifikuojant. Tyrimo tikslas – patikrinti sukurtą stebėjimo instrumentą, kuriuo būtų galima užfiksuoti sinchroniškumą ir spontaniškas sąveikas tarp šokėjų.

Metodai. Sukurtas tyrimo instrumentas buvo taikomas ryšiams tarp grupės narių atskleisti nagrinėjant sąveikas tarp šokėjų, sinchroniškumą tarp jų, fizinį kontaktą ir bendrąjį erdvės suvokimą. Septyni šokėjai improvizavo per keturis penkių minučių trukmės pratimus, kurių metu buvo atliekami keturi skirtingi privalomieji elementai (laisvas judėjimas; laisvas judėjimas, prieš tai vieną minutę kvėpuojant visiems tuo pačiu metu (sinchroniškai); vien tik vaikščiojimas ir mojavimas rankomis; laisvas judėjimas – kai vienas šokėjas sustoja ir visi staiga tą turi padaryti. Duomenys registruoti *MachVision Studio* programa, analizuojami – naudojant „Theme v.5“ programą (Magnusson, 1996, 2000).

Rezultatai. Nustatyti T-modeliai (20 per pirmą pratimą, 11 per antrą, 21 per trečią ir 8 per ketvirtą) ir užregistruotų judesių apraiškų dažnumas rodo, kad: 1) sukurtas stebėjimo instrumentas leidžia analizuoti šokėjų judesių sinchroniškumo kaitą ir šokėjų tarpusavio sąveiką, taip pat nustatyti pasikartojančias judesių sekas; 2) dažniausiai pasikartojantis modelis yra kontaktas šokant poroje; 3) privalomi šokio elementai riboja pasitaikančių modelių įvairovę; 4) išankstinis kvėpavimo suderinimas sustiprino grupės judesių sinchroniškumą ir fizinį kontaktą tarp šokėjų.

Aptarimas ir išvados. Sukurtas tyrimo instrumentas leidžia analizuoti judesių sinchroniškumo ir šokėjų tarpusavio sąveiką, pasikartojančius šokio elementų modelius.

Raktažodžiai: stebėjimo metodologija, sinchroniškumas, privalomi elementai, netiesinis elgesys.

Corresponding author **Carlota Torrents Martín**
Laboratori d'Observació de la Motricitat
Inefc-Lleida
Partida de la Caparrella s / n
25192. Lleida
Catalunya - Spain
Tel +34 973272022
E-mail carlotat@inefc.es

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Lietuvos kūno kultūros akademija, Sporto g. 6, LT-44221 Kaunas

E-mail *zurnalas@lkka.lt*

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2.7. **Rezultatų aptarimas.** Aptarimo pradžioje rekomenduojame pateikti pagrindinius originalius straipsnio teiginius (išvadas), kilusius iš tyrimo duomenų. Rezultatų aptarimą būtina struktūrizuoti išskiriant potemes (kiekvieną originalų atrastą teiginį rekomenduojame aptarti atskira poteme). Tyrimo rezultatai ir išvados lyginami su kitų autorių skelbtais duomenimis, įvertinami jų tapatumai ir skirtumai. Ypač svarbu pabrėžti tyrimo duomenų originalumą. Reikia vengti kartoti tuos faktus, kurie pateikti tyrimų rezultatų dalyje.

2.8. **Išvados ir perspektyvos.** Išvados turi būti formuluojamos aiškiai ir logiškai, vengiant tuščiažodžiavimo. Išvados turi būti pagrįstos tyrimo rezultatais ir patvirtinti arba paneigti tyrimo hipotezę. Svarbiausias išvadų reikalavimas – jos turi būti pasaulyje originalios. Būtina nurodyti tolesnių tyrimų perspektyvas.

2.9. **Padėka.** Dėkojama asmenims arba institucijoms, padėjusiems atlikti tyrimus. Nurodomos organizacijos ar fondai, finansavę tyrimus (jei tokie buvo).

2.10. **Literatūra.** Cituojami tik publikuoti mokslo straipsniai ir monografijos (išimtis – apgintų disertacijų rankraščiai). Į sąrašą įtraukiami tik tie šaltiniai, į kuriuos yra nuorodos straipsnio tekste. Mokslinio straipsnio literatūros sąrašas neturėtų viršyti 20 šaltinių, apžvalginio – 30.

3. Straipsnio įforminimo reikalavimai

3.1. Straipsnio tekstas turi būti išspausdintas kompiuteriu vienoje standartinio A4 formato (210 × 297 mm) balto popieriaus lapo pusėje, intervalas tarp eilučių 6 mm (1,5 intervalo), šrifto dydis 12 pt. Paraštės: kairėje – 3 cm, dešinėje – 1,5 cm, viršuje ir apačioje po 2,5 cm. Puslapiai numeruojami apatiniame dešiniajame krašte, pradedant tituliniu puslapiu, kuris pažymimas pirmu numeriu (1).

3.2. **Straipsnis turi būti suredaguotas, spausdintas tekstas patikrintas.** Pageidautina, kad autoriai vartotų tik standartinius sutrumpinimus ir simbolius. Nestandartinius galima vartoti tik pateikus jų apibrėžimus toje straipsnio vietoje, kur jie įrašyti pirmą kartą. Visi matavimų rezultatai pateikiami tarptautinės SI vienetų sistemos dydžiais. Straipsnio tekste visi skaičiai iki dešimt imtinai rašomi žodžiais, didesni – arabiškais skaitmenimis.

3.3. Tituliniame straipsnio lape pateikiama: a) trumpas ir informatyvus straipsnio pavadinimas (ne daugiau kaip 80 raidžių); b) autorių vardai ir pavardės; c) institucijos, kurioje atliktas tyrimas, pavadinimas; d) autoriaus, atsakingo už korespondenciją, susijusią su pateiktu straipsniu, vardas, pavardė, adresas, telefono numeris, elektroninio pašto adresas. Jei autorius nori turėti slaptos recenzijos teisę, pridedamas antras titulinis lapas, kuriame nurodomas tik straipsnio pavadinimas. Tituliniame lape turi būti visų straipsnio autorių parašai.

3.4. Santraukos anglų ir lietuvių kalbomis pateikiamos atskiruose lapuose. Tame pačiame lape surašomi raktažodžiai.

3.5. Lentelė (pageidautina ne daugiau kaip 3–4 lent.) turi turėti eilės numerį (numeruojama ta tvarka, kuria pateikiamos nuorodos tekste) ir trumpą antraštę. Visi paaiškinimai turi būti straipsnio tekste arba trumpame prieraše, išspausdintame po lentele. Lentelėse vartojami simboliai ir sutrumpinimai turi sutapti su vartojamais tekste. Lentelės vieta tekste turi būti nurodyta kairėje paraštėje (pieštuku).

3.6. Paveikslai (pageidautina ne daugiau kaip 4–5 pav.) sužymimi eilės tvarka arabiškais skaitmenimis. Pavadinimas rašomas po paveikslu, pirmiausia pažymint paveikslo eilės numerį, pvz.: 1 pav. Paveikslo vieta tekste turi būti nurodyta kairėje paraštėje (pieštuku). Paveikslus prašytume pateikti atviru formatu (kad būtų galima redaguoti).

3.7. Literatūros sąraše šaltiniai nenumeruojami ir vardijami lotynų abėcėlės tvarka pagal pirmojo autoriaus pavardę. Pirma vardijami šaltiniai lotyniškais rašmenimis, paskui — rusiškais. Pateikiant žurnalo (mokslo darbų) straipsnį, turi būti nurodoma: a) autorių pavardės ir vardų inicialai (po pavardės); b) žurnalo išleidimo metai; c) tikslus straipsnio pavadinimas; d) pilnas žurnalo pavadinimas; e) žurnalo tomas, numeris; f) atitinkami puslapių numeriai. Jeigu straipsnio autorių daugiau kaip penki, pateikiamos tik pirmų trijų pavardės priduriant „et al." arba „ir kt."

Aprašant knygą, taip pat pateikiamas knygos skyriaus pavadinimas ir jo autorius, knygos leidėjas (institucija, miestas).

Jeigu to paties autoriaus, tų pačių metų šaltiniai yra keli, būtina literatūros sąraše ir straipsnio tekste prie metų pažymėti raides, pvz.: 1990 a, 1990 b ir t. t.

Literatūros aprašo pavyzdžiai:

Gikys, V. (1982). *Vadovas ir kolektyvas*. Vilnius: Žinija.

Jucevičienė, P. (Red.) (1996). *Lyginamoji edukologija*. Kaunas: Technologija.

Miškinis, K. (1998). *Trenerio etika: vadovėlis Lietuvos aukštųjų mokyklų studentams*. Kaunas: Šviesa.

Ostasevičienė, V. (1998). Ugdymo teorijų istorinė raida. A. Dumčienė ir kt. (Red. kol.), *Ugdymo teorijų raidos bruožai: teminis straipsnių rinkinys* (pp. 100–113). Kaunas: LKKI.

Šveikauskas, Z. (1995). Šuolių technikos pagrindai. J. Armonavičius, A. Buliuolis, V. Butkus ir kt., *Lengvoji atletika: vadovėlis Lietuvos aukštųjų m-klų studentams* (pp. 65–70). Kaunas: Egalda.

Večkienė, N., Žalienė, I., Žalys, L. (1998). *Ekonominis švietimas – asmenybės ugdymo veiksnys. Asmenybės ugdymo edukologinės ir psichologinės problemos: respublikinės moksl. konferencijos medžiaga* (pp. 159–163). Kaunas: LKKI.

Vitkienė, I. (1998). Kai kurių mikroelementų pokyčiai lengvaatlečių kraujyje fizinio krūvio metu. *Sporto mokslas*, 1 (10), 12–13.

INFORMATION TO AUTHORS

1. General information

1.1. All papers submitted to the journal should contain original research not previously published (except preliminary reports or conference thesis). The material published in the journal should be new, true to fact and precise. The methods and procedures of the experiment should be identified in sufficient detail to allow other investigators to reproduce the results. It is desirable that the material to be published should have been discussed previously at conferences or seminars.

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2.1. **The title page** contains the title of the article; the authors' names and surnames; the names of the institutions where the authors work or study (indicating the city and the country); the address for correspondence.

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2.8. **Conclusions and perspectives.** The conclusions provided should be formulated clearly and logically avoiding excessive verbiage. Conclusions supported by the research results should confirm or reject the research hypothesis. The most important requirement for the research conclusions is their originality in the world. It is necessary to indicate the further perspectives of the research.

2.9. **Acknowledgements.** On the Acknowledgement Page the authors are required to state all funding sources, and the names of companies, manufacturers, or outside organizations providing technical or equipment support (in case such support had been provided).

2.10. **References.** Only published materials (with the exception of dissertations) and sources referred to in the text of the article should be included in the list of references. There should not be more than 20 references for original investigations and 30 references for review articles.

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3.3. The title page should contain: a) a short and informative title of the article (no more than 80 characters without spaces); b) the first names and family names of the authors; c) the name and the address of the institution and the department where the work was done; d) the name, address, phone number, E-mail number, etc. of the author to whom correspondence should be sent. If a blind review is requested a second title page that contains only the title is needed. The title page should be signed by all authors of the article.

3.4. Abstracts in the Lithuanian and English languages are supplied on separate sheets of paper. This sheet also should contain keywords.

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Examples of the correct format are as follows:

Bergman, P. G. (1993). Relativity. In *The New Encyclopedia Britannica* (Vol. 26, pp. 501–508). Chicago: Encyclopedia Britannica.

Bjork, R. A. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H. L. Roediger III, F. I. M. Craik (Eds.), *Varieties of Memory & Consciousness* (pp. 309–330). Hillsdale, N J: Erlbaum.

Deci, E. L., Ryan, R. M. (1991). A motivational approach to self: Integration in personality. In R. Dientsbier (Ed.), *Nebrasha Symposium on Motivation: Vol. 38. Perspectives on Motivation* (pp. 237–228). Lincoln: University of Nebraska Press.

Gibbs, J. T., Huang, L. N. (Eds.). (1991). *Children of Color: Psychological Interventions With Minority Youth.* San Francisco: Jossey–Bass.

Ratkevičius, A., Skurvydas, A., Lexell, J. (1995). Submaximal exercise-induced impairment of human muscle to develop and maintain force at low frequencies of electrical stimulation. *European Journal of Applied Physiology,* 70, 294–300.

Town, G. P. (1985). *Science of Triathlon Training and Competition.* Champaign, Illinois: Human Kinetics.

Vadovėlyje nagrinėjami didžiojo sporto psichologijos tyrimo metodai, sportinės karjeros psichologiniai ypatumai, psichologinės paramos sportininkui ypatumai, didelio meistriškumo sportininkų sujaudinimo, streso, nerimo, motyvacijos ypatumai, sportininkų bendravimo dėsningumai, psichologinės paramos sportininkui po traumų bruožai, sportininkų psichologinių įgūdžių ugdymo ypatumai, didžiojo sporto socialinės prigimties tyrimų dėsningumai, agresijos didžiajame sporte poreiškiai, didelio meistriškumo sportininkų trenerio psichologija.

Skiriamas Lietuvos kūno kultūros akademijos sporto psichologijos studijų programos magistrantams, VPU ir ŠU studentams, studijuojantiems sporto psichologiją, kūno kultūros ir sporto specialistams.