THE QUANTITATIVE CHANGES OF STUDENTS' MOTOR ABILITIES PRODUCED BY A 12-WEEK COMBINED FITNESS PROGRAM

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Abstract
The aim of the study was to find out partial quantitative changes of students' motor abilities, produced by applied 12-week combined fitness program. All participants were health sport faculty male students with ages 19 ± 1. The experimental program included a three times work out per week, two times resistance, weight training and once a week plyometric training. In order to detect potential changes we conducted paired sample t-test. The obtained results showed that the program has made statistically significant changes on 14 of 18 tests. The highest level of transformation has made on variables for static and repetitive strength assessment. The improvement was between 18 and 55 percent. Also, less, but no less significant changes have been produced on explosive power, flexibility and segmental speed tests. We think, that fine adjusted training load to all participants, respectively, an individualised approach, contributed to exceptional results. Our opinion is that this kind of fitness program should be part of regular faculty program during all educational period, in order to enhance students' motor capacities and make their way to the finish line easier.

Key words: *fitness program, motor abilities, changes, paired sample t-test*

Introduction

Motor abilities are inseparable part of every person. The level of motor ability's development, capacity and heredity are something that discriminate one person from other. A permanent interest of kinesiology researchers is how to produce their, in an optimum way, positive transformations, respectively, to make the biggest possible effects in the shortest time. It is known that an exercise is a stress that body needs to deal with. Only if the next stressor is more intense than previous one, we can expect that cumulative effects of training will occur. Therefore, it is not hard to conclude that just an appropriate choice of kinesiology operators, adjusted to every person, can create wanted effects. Long-term adaptation to the stress (an exercise), that actually happens between two training sessions, is the main goal of every programmed physical activity. A body is led out from state of homeostasis in order to make him more resistible to an external load i.e. faster, stronger, and more enduring than it was before some fitness program was applied. An examination of different kind of fitness programs, loads, exercise's volume and intensity, rest intervals, training methods are some of field of interests when we talk about exercising and its effects on anthropological status of person.

These kinds of researches have produced a conception of different fitness programs and methods for motor abilities improvement, as various resistance and weight training, vibration training, electro stimulation, proprioception training, plyometrics training, interval and fartlek training etc. This research concerns effects of combine fitness training, which consists of two trainings; a weight training and plyometrics, on eighteen motor tests that cover six hypothetically established motor dimensions. According to Fleck, S.J. and Kraemer, W.J. (2004), "high velocity plyometrics which consist of a rapid eccentric muscle action followed by a powerful concentric muscle action are important for enhancing the rate of force development during jumping and sprinting, whereas heavy resistance training is needed to enhance muscular strength and acceleration". Previous researches, conducted with similar goal and with more criterion variables, have been carried out by Avery D. F. at al. (2007), who compared effects of six weeks combine plyometrics and resistance training with resistance training alone. Although, both groups showed improvement in all tested variables, (vertical jump, long jump, medicine ball toss, 9.1 m sprint, pro agility shuttle run and flexibility), the plyometrics-resistance group demonstrated better results than resistance group alone.

These findings suggest that the addition of plyometric training to a resistance training program may be more beneficial than resistance training and static stretching for enhancing selected measures of upper and lower body power in boys. Other studies mostly compare effects of mentioned programs (combined plyometrics-resistance and resistance training alone) on vertical jump performance. Adams et al. (1992) evaluated efficancy of three different programs (squat training, plyometrics, and combination) on vertical jump height. The subjects who performed a combined training achieved a statistically greater improvement. The results indicate that both squat and plyometrics training are necessary for improving hip and thigh power production as measured by vertical jumping ability. Fatouros et al. (2000) reported that subjects who performed 12-week combined training program have achieved statistically the greatest enhancement in vertical jump ability. The other researches which results are going to be quoted in this paper, mainly dealt with effects of plyometrics training on explosive power of lower and upper limbs, and agility.

Methods

Participants

Thirty six actually healthy college male students with ages 19 ± 1 year participated in this study. All participants chose subject Fitness as an optional course. All of them had shorter or longer history of physical activity participation, but during the study they were not included in any organised sport activity except those related with the research. Only participants who had hundred percent of training session attendance have been considered in the examination.

Instruments

The sample of variables consisted of an 18-test battery of measuring instruments assessing motor abilities. The analyzed motor tests covered the following hypothetical motor abilities: segmental speed: (MBFTAP – an arm plate tapping , MBFTAN – a foot plate tapping, and MBFTAZ – a foot tapping on a wall), flexibility (MFLBOS – a side leg stretch, MFLISK – a twist with the stick, and MFLPRK – a sit and reach), explosive power: (MFESSVM – a vertical jump, MFETRO – a triple jump from standing position, and MFEBML – a medicine ball toss), repetitive strength: (MRESKL – push ups, MREPTL – sit ups, and MRCZTL – a back extension), static strength (MSLIZP –a squat position maintenance, MSAVIS – a bent-arm hang, and MSCHIL – a horizontal maintenance) and agility and total body coordination: (MAGKUS - 4 meters shuffle steps, MAGTUP –a zig-zag test, and MAGOSS – a figure eight running). In following tables variables are written with letter "I" or "F" at the end of all variables' acronyms. The letters represent initial and final testing session variables. The assessment was carried out in University sport hall in morning hours.

Experimental program

The realised fitness program consisted of two programs combination; the weight training (two times a week) and plyometrics (once a week). The program was carried out in the first semester of school year and it lasted for twelve weeks. Before participants started with weight training, they had been tested by sixteen weight lifting exercises (bench press, squat, hang clean, leg press, step ups, leg extension, leg curl, leg adduction and abduction, back extension, sit ups, sitting military press, triceps press downs, lat pull-downs, barbell upright row, standing curl bar curls) in order to get their 1 RM - repetitium maximum (the maximal load a person can lift in one attempt). Based on 1-RM the exercises' intensity has been determined for each participant. Prior the weight training subjects performed 15-minut warm up. The exercises' intensity has increased linearly from week to week as participants get stronger. Because the subjects were beginners in weight training, first two weeks of the program were designed in order to prepare their musculoskeletal system for the following training and to learn proper techniques and principles of this kind of resistance training. The rest of program was created to enhance muscular endurance and hypertrophy, and, as the program was approaching to the end, participants had to deal with sub maximal and maximal exercise's intensity which implicated maximal power enhancement. A number of series, repetitions and rest intervals were determined according to recommendations for beginners: "Training loads characterized by one to three series, with eight to twelve repetitions, intensities of 70 to 85% of 1MR and pauses between one and two minutes, correspond to the recommendations for muscular hypertrophy training with amateur/intermediate individuals".

The second part of the program was related to plyometrics training. "Plyometrics refers to human movement that involves an eccentric muscle contraction immediately and rapidly followed by a concentric contraction. Plyometrics is a type of exercise training designed to produce fast, powerful movements (jumps, sprints, throws...), and improve the functions of the nervous system" [(3)]. Fifteen minutes warm up was standard procedure prior to plyometric exercises. In first two weeks subjects have met plyometrics training, its principles and safety consideration, and using low intensity exercises (skips, sprints, hops, double-leg jumps in place, running in place, skipping rope and side to side jumps over a small barrier) gradually reached more intense exercises, that included different depth jumps and medical balls toss. By means of different bench heights for drop jumps and different medical ball weights we successfully controlled the work out intensity. The types of exercises and its intensity was determined according to the book "Jumping into plyometrics" (1998), written by Chu, D.A.

Results

Using a paired sample t-test we tried to ensure if the 12-week combined fitness program had produced any partial quantitative effects on tested variables. Two testing sessions were carried out; an initial, before the start of the program, and the other, a final assessment, after the program realisation. Table 1 shows descriptive statistic for all variables. As it noticeable all final variables' values have been increased comparing them with their initial pairs, except time determined variables where lower value means better result. Pre-post standard deviation values reveal that participants had the highest variability in variables for static and explosive strength estimation, but the lowest variability in variables for segmental speed and agility evaluation.

Table 1. Paired samples statistics

pairs	variables	Mean	N	Std. Dev.	Std. Error Mean
Pair 1	MBFTAPI	40,53	36	1,99	0,332
	MBFTAPF	44,56	36	2,84	0,474
Pair 2	MBFTANI	43,28	36	4,58	0,764
	MBFTANF	44,75	36	3,24	0,54
Pair 3	MBFTAZI	24,97	36	2,99	0,498
	MBFTAZF	26,31	36	3,02	0,504
Pair 4	MFLBOSI	175,44	36	15,24	2,54
	MFLBOSF	179,86	36	13,00	2,167
Pair 5	MFLISKI	82,44	36	13,13	2,188
	MFLISKF	79,03	36	12,91	2,152
Pair 6	MFLPRKI	29,35	36	9,95	1,659
	MFLPRKF	31,33	36	9,23	1,539
Pair 7	MFESSVMI	49,78	36	6,25	1,041
	MFESSVM	54,92	36	7,33	1,222
Pair 8	MFETROI	687,5	36	54,00	9,001
	MFETROF	709,72	36	51,59	8,598
Pair 9	MFEBMLI	125,94	36	17,46	2,911
	MFEBMLF	134,47	36	15,12	2,519
Pair 10	MRESKLI	26,44	36	9,61	1,60
	MRESKLF	34,78	36	9,77	1,63
Pair 11	MREPTLI	17,56	36	7,48	1,25
	MREPTLF	23,83	36	7,39	1,23
Pair 12	MRCZTLI	36,08	36	13,50	2,25
	MRCZTLF	44,11	36	12,80	2,15
Pair 13	MSLIZPI	27,73	36	18,30	3,05
	MSLIZPF	61,8	36	39,80	6,64
Pair 14	MSAVISI	56,14	36	18,30	3,05
	MSAVIS	59,36	36	16,90	2,82
Pair 15	MSCHILI	24,94	36	11,60	1,93
	MSCHILF	32,34	36	14,90	2,49
Pair 16	MAGKUSI	8,55	36	1,19	0,20
	MAGKUSF	8,35	36	0,80	0,13
Pair 17	MAGTUPI	24,45	36	1,48	0,25
	MAGTUPF	24,32	36	1,31	0,22
Pair 18	MAGOSSI	17,64	36	1,45	0,24
	MAGOSSF	16,77	36	1,09	0,18

Table 2 shows statistically significant correlation between every pre-post variable, excluding variable MBFTAPN, which shows enhancement, but it is not consistent across all subjects, i.e. several subjects improved their results, but several others did not.

Table 3, - "Mean" illustrates average differences of pre-post variables, that is, the effects produced by the 12-week fitness program realisation. The biggest differences are evident with variables for static and dynamic muscular endurance, and with variable a triple jump from standing position.

The t-test values are statistically significant for fourteen of eighteen variables, that means, the produced effects can be attributed to the accomplished fitness program.

Table 2. Paired samples correlations

pairs	variable	Corr	Sig.
Pair 1	MBFTAP	,577	,000
Pair 2	MBFTAN	,265	,119
Pair 3	MBFTAZ	,785	,000
Pair 4	MFLBOS	,899	,000
Pair 5	MFLISK	,785	,000
Pair 6	MFLPRK	,931	,000
Pair 7	MFESSV	,835	,000
Pair 8	MFETRO	,870	,000
Pair 9	MFEBML	,855	,000
Pair	MRESKL	,853	,000
Pair	MREPTL	,475	,003
Pair	MRCZTL	,673	,000
Pair	MSLIZP	,664	,000
Pair	MSAVIS	,802	,000
Pair	MSCHIL	,663	,000
Pair	MAGKUS	,541	,001
Pair	MAGTUP	,710	,000
Pair	MAGOSS	,580	,000

That was not a case with four variables, which t-test values are not statistically significant, although, there are some average differences between pre-post results, but they are not consistent across all subjects, i.e. several subjects improved their results, but several others did not. The produced outcome of these four variables cannot be attributed to the program.

Table 4 shows a percentage of the effects produced by the applied fitness program. The variables in the table are arranged according to percentage values; from the highest to the lowest. As it evident, the highest changes are made on variables for static and repetitive strength estimation. It was expected because the tested abilities are genetically very low determined. A static strength of lower limbs increased for 55%. Isometric and dynamic endurance of abdomen muscles enhanced for 25 and 26%. The repetitive strength of upper limbs and back muscles increased for 24 % and 18 %. As it obvious, results in other variables increased for 10% or less, whereas, there were not any statistically significant effects on variables (MBTAZ, MSAVIS, MAGKUS and MAGTUP).

Table 3. Paired sample test

pairs	variables	Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Dev.	Std. E. Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MBFTAPI - MBFTAPF	-4,03	2,35	,39	-4,82	-3,23	-10,29	35	,000
Pair 2	MBFTANI - MBFTANF	-1,47	4,86	,81	-3,11	,17	-1,81	35	,078
Pair 3	MBFTAZI - MBFTAZF	-1,33	1,97	,33	-2,00	-,67	-4,05	35	,000
Pair 4	MFLBOSI - MFLBOSF	-4,42	6,72	1,11	-6,68	-2,14	-3,94	35	,000
Pair 5	MFLISKI - MFLISKF	3,42	8,55	1,42	,53	6,30	2,39	35	,022
Pair 6	MFLPRKI - MFLPRKF	-1,99	3,64	,61	-3,21	-,75	-3,27	35	,002
Pair 7	MFESSVMI - MFESSVMF	-5,14	4,04	,67	-6,50	-3,77	-7,63	35	,000
Pair 8	MFETROI - MFETROF	-22,22	27,03	4,50	-31,36	-13,07	-4,93	35	,000
Pair 9	MFEBMLI - MFEBMLF	-8,52	9,06	1,51	-11,59	-5,46	-5,64	35	,000
Pair 10	MRESKLI - MRESKLF	-8,33	5,26	,88	-10,11	-6,55	-9,50	35	,000
Pair 11	MREPTLI - MREPTLF	-6,27	7,62	1,27	-8,85	-3,69	-4,94	35	,000
Pair 12	MRCZTLI - MRCZTLF	-8,02	10,69	1,78	-11,64	-4,41	-4,50	35	,000
Pair 13	MSLIZPI - MSLIZPF	-34,07	30,89	5,14	-44,52	-23,61	-6,61	35	,000
Pair 14	MSAVISI - MSAVIS	-3,21	11,16	1,86	-6,99	,56	-1,73	35	,093
Pair 15	MSCHILI - MSCHILF	-7,40	11,32	1,88	-11,23	-3,57	-3,92	35	,000
Pair 16	MAGKUSI - MAGKUSF	,20	1,02	,17	-,14	,54	1,17	35	,246
Pair 17	MAGTUPI - MAGTUPF	,13	1,08	,18	-,24	,49	,71	35	,480
Pair 18	MAGOSSI - MAGOSSF	,87	1,21	,20	,46	1,27	4,30	35	,000

Table 4. Percentage of the effects produced by the applied fitness program

Number	VARIABLES	Motor ability that is tested	Percentage of produced effect
1.	MSLIZP – squat position maintenance	static strength of lower limbs	55,00 %
2.	MREPTL – sit ups	repetitive strength of abdomen	26,32 %
3.	MSCHIL – horizontal position maintenance	static strength of abdomen	25,00 %
4.	MRESKL – push ups	repetitive strength of arms and shoulders	24,00 %
5.	MRCZTL – back extension	static strength of back	18,21 %
6.	MFESSVM – vertical jump	Explosive power of lower limbs	9,36 %
7.	MBFTAP – arm plate taping	Segmental speed	9,00 %
8.	MFEBML – medicine ball toss	Explosive power of upper limbs	6,35 %
9.	MFLPRK – sit and reach	Trunk flexibility	6,33 %
10.	MBFTAZ - a foot tapping on a wall	Segmental speed	5,10 %
11.	MAGOSS – eight figure run	Agility	5,00 %
12	MFLISK –twist with the stick	Flexibility of arms and shoulders	4,14 %
13.	MFETRO – triple jump from standing position	Explosive power of lower limbs	3,14 %
14.	MFLBOS - a side leg stretch	Lower limbs flexibility	1,35 %

Discussion

Observing the obtained results, it is obvious that realised program have produced the partial quantitative changes on fourteen of eighteen variables for motor abilities evaluation. The highest effects have been produced on variables for muscular static and dynamic endurance. The reasons for this we can find in the weight training design, especially, in its first part when the participants had to deal with smaller loads and big number of exercise's series and number of repetitions.

The program effects on explosive power tests (a vertical jump, a medicine ball toss and a triple jump from standing position) are smaller, but not less significant because explosive power is ability that is genetically high determined, i.e. it is very hard to make any transformation, so every change made on this ability is valuable. The combined program, especially plyometrics part, has produced the highest effects on a vertical component of jumping ability (9,3 %), than on the horisontal component and musculo-tendonos system reactibility (3,14%), and on explosive power of upper limbs (6,35 %). The effects' percentage produced on explosive power is compatible with results found by Fatouros and colleagues (2000). They reported that after 12 weeks of training, adult subjects, who combined plyometric training with resistance training, increased vertical jump performance by 15%, whereas gains of 11% and 9% were reported for subjects who performed only resistance training or plyometric training, respectively. Other studies examine just effects of plyometric training. Marković (2007), based on data extracted from 26 different studies about the plyometric training effects on jumping ability, reported that " Plyometric training provides a statistically significant and practically relevant improvement in vertical jump height with the mean effect ranging from 4.7% (squat and drop jump), over 7.5% (countermovement jump – arms swing) to 8.7% (countermovement jump – free arms).

These results justify the application of plyometric training for the purpose of development of vertical jump performance in healthy individuals".Matavulj et al. (2001) carried out two experimental plyometrics training for jumping performance improvement of young basketball players. The both groups improved their vertical jump height (4.8 i 5.6 cm) that is also compatible with our findings (5,14 cm; table 3). Vossen, J.F. et Al. (2000) compared "dynamic push up and plyometric push-up training programs on 2 criterion measures: a medicine ball toss and the maximum weight for 1 repetition of a sitting, 2-handed chest press.

The plyometrics group experienced significantly greater improvements than the other group on the medicine ball put, while there was no significant difference between groups for the chest press, although the plyometrics group experienced greater increases". It is possible that the program i.e. its plyometrics part could be designed with bigger number of depth jumps exercises, but because of safety considerations, and recommendations for training with amateur/intermediate individuals, it was not a case in our study. More intense plyometrics exercises can be involved in a training program of well experienced athletes and examined in some future research. Although, there is a stereotypic opinion that a weight training decrease flexibility, the study confirmed, once again, that is not true.

The applied program produced, although, small effects (1, 35 % and 6, 35 %), after all, we talk about a positive transformation, but not negative. Better improvement it is possible to achieve by different kind of stretching training and exercises before, during and after every workout. Once again, we emphasize that weight and plyometrics training do not change flexibility in a negative way. The program produced effects only on one (a figure eight running – 5 %) of three variables for agility estimation. This fact can be considered as a deficiency of applied program because some other studies, as research conducted by Michael G. Miller et al. (2006) with the purpose of the study to determine if six weeks of plyometric training can improve an athlete's agility, assessed by two tests T-test and Illinois Agility Test.

They confirmed that plyometric training can be an effective training technique to improve an athlete's agility. Probably, their program involved bigger number of sprint exercises with quick change of direction, while that was not a case in our program. Also, this incompatibility can be a result of different tests that been used in this research.

Conclusion

The twelve weeks combined fitness program has produced statistically significant partial quantitative effects on students' motor abilities, so it can be said, that established hypothesis is confirmed. The applied program has generated improvement of fourteen variables of eighteen assessed variables. These changes are product of well planed and programmed work out, and individually, based on 1 RM, adjusted training load and intensity. The biggest changes are produced on variables for muscular static and dynamic endurance, what was expected in considerations of two facts: the first, the mentioned abilities are not high genetically determined, and the second, the program has been designed in order to improve a repetitive strength. Also, proportionally less, but not less significant changes have been produced on variables for explosive power estimation. These paper findings are compatible with other studies that examined effects of heavy weight and plyometrics training. A stereotypic belief, that weight training decrease flexibility, has been refused. Based on obtained results, it is obvious, that flexibility has been improved by the program, but not negatively influenced. The advantage of this research is getting information about the combined, weight and plyometrics training effects on big number of criterion variables, as was not a case in available literature.

The other studies, mostly tried to check effects of different programs on jumping performance. As a deficiency of this study, it can be taken a lack of experimental groups and control group, as can contribute to a reduced amount of reliable knowledge of the experimental program. This can be a construction of some future study. The applied program has proved its efficiency in motor abilities transformation and it could be a good method for students of sport faculty to improve and develop their motor capacities in order to easily pass all faculty duties, especially practical part of exams.

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KVANTITATIVNE PROMJENE MOTORIČKIH SPOSOBNOSTI STUDENATA NASTALE POD UTICAJEM KOMBINOVANOG DVANAESTOSEDMIČNOG FITNESS PROGRAMA

Sažetak

Na uzorku od 36 studenata Fakulteta za tjelesni odgoj i sport, dobi 19 ± 1 godina, primjenjen je kombinovani dvanaestosedmični fitnes program, koji se sastojao od dva treninga sedmično s tegovima u teretani i pliometrijskog treninga jedanput sedmično. Obzirom na cilj rada, da se utvrde eventualne parcijalne kvantitativne promjene testiranih motoričkih sposobnosti nastale pod uticajem provedenog programa, korišten je t-test za zavisne uzorke. Na osnovu dobijenih rezultata vidimo da je provedeni program proizveo statistički značajne promjene na 14 od testiranih 18 varijabli. Najveći nivo promjena desio se na varijablama za procjenu statičke i repetitivne snage, i to od 18 % do 55 %. Također, manje ali ne beznačajnije promjene evidentne su na testovima za procjenu eksplozivne snage, fleksibilnosti i segmentarne brzine. Individualno prilagođeno opterećenje svakom ispitaniku, zasigurno je proizvelo ove značajne promjene. Smatramo da bi program trebao biti ugrađen u redovni plan nastave na svim godinama, kako bi doprinjeo povećanju motoričkih kapaciteta studenata, te im olakšao put do cilja, završetka fakulteta.

Ključne riječi*: fitnes program, motoričke sposobnosti, promjene, t-test za zavisne uzorke*

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