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Effect of Programmed Kinesiologic Treatment on Structural Transformation of Some Strength and Endurance Manifestations in Croatian Army Draftees

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A B S T R A C T

Structural, i.e. qualitative changes in some motor dimensions (strength and endurance) were assessed during a 2-month period in a sample of 307 male subjects, Croatian Navy draftees, mean age 21 years. Study subjects were divided into three groups: experimental group 1 (n = 102), experimental group 2 (n = 97) and control group (n = 108), submitted to different kinesiologic treatments. The structure of isolated dimensions for 13 motor variables showed significant changes between two time points (two transitive states) in all three groups of subjects. In experimental groups, the treatments influenced the highest correlation of repetitive strength and aerobic endurance, with this very dimension integrating these capabilities at the second time point. Second dimension integrated explosive strength and anaerobic capacity, whereas third dimension integrated repetitive strength of the trunk and aerobic endurance in experimental group 1. In the control group of subjects, repetitive strength, aerobic endurance and anaerobic capacity were isolated as specific dimensions.

Introduction

The aim of treatments performed in ground, air or naval forces almost regularly is to simultaneously influence the development of aerobic and muscular endurance along with muscular tissue increase and adipose tissue reduction[1,2].

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The treatments used in military forces always tend to the formation of anthropologic complexes appropriate for performance of specific combat activities[3].

In their study carried out in members of the American Army Military Academy, Patton et al.[4] found that daily running of 2–4 miles for 6 months in addition to the regular training schedule significantly improved maximal oxygen consumption. Basic military training has also been reported to improve maximal oxygen consumption[5–8]. Stacy et al.[1] analyzed the effects of elementary recruit training on aerobic capacity and fat percentage in New Zealand military forces. After 10-day basic training, maximal VO_2 increased by 16%, whereas fat percentage decreased from 12.4% to 10.2%, with no change in body weight. In South African Army recruits, Gordon et al.[2,9] recorded the one-year military training to entail favorable changes in lactate tolerance, repetitive strength, absolute strength, strength and endurance. In his study, Rudzki[10] assessed the efficiency of full-pack march as a method of recruit conditioning in Australian military forces. Stevenson et al.[11,12] have developed standards for the Canadian Army personnel that include measures of aerobic capacity and strength, separately for the subjects aged < 35 and > 35.

Knapik et al.[13] investigated the correlation of age, physical training, and measures of muscular and cardiovascular endurance. A sample of 5,079 US Army members aged 18–53 years from 14 US Army bases underwent three tests: 3,200-m running, 2-min ground pushups, and 2-min forward trunk bending. The amount of training was determined from the number of training sessions and total training performed by an individual *per* week. The ability of performing all three tests was found to significantly decrease with age and lack of training. The highest effect of training was recorded in cardiorespiratory endurance. Legg et al.[14] determined the effects of basic recruit training in older artillerist recruits, young recruits, and young recruits on reserve officer training in British army. Schiotz et al.[15] found that 10-week training program significantly improved body composition, strength and measures of fitness components (which consisted of ground pushups, knee-bends, 2-mile running and 10-km hurdles), and that the two different training programs with identical relative load volumes applied could be equally used in basic training. Hoffman et al.[16] observed the draftees with under-average strength results to be at a 5-fold risk to sustain fractures during training found in other recruits. Maleš et al.[3] determined the effects of specially designed kinesiologic 4.5-month treatment on quantitative changes of some motor capabilities in a Croatian Army (CA) special unit, which manifested through three factors: development of repetitive strength, development of aerobic endurance on marching, running and hurdles, and development of aerobic endurance on swimming.

The present study was focused on the analysis of qualitative, i.e. structural changes of motor abilities relevant for the military force efficiency in specific tasks (factors of strength and endurance) as influenced by differently designed kinesiologic treatments.

The main aim of the study was to determine the effect of specially designed kinesiologic treatments assessed at two time points on qualitative changes of motor capabilities in naval draftees attending specialist military training in Croatian Navy.

Subjects and Methods

The study was conducted in a sample of 307 male subjects, Croatian Navy draftees attending specialist naval training, mean age 21 years, free from health problems and eligible for doing service in Croatian military forces. Study subjects were divided into three groups: experimental group 1 (n = 102), experimental group 2 (n = 97) and control group (n = 108), submitted to different kinesiologic treatments so designed as to influence the strength and endurance development, in addition to mastering particular motor concepts and skills. The three kinesiologic treatments differed primarily in the frequency, duration and intensity of individual training units.

Experimental group 1 subjects underwent one 15-min training unit of moderate and/or high intensity daily in addition to regular 20-min morning training. Experimental group 2 subjects performed three 90-min training units of moderate intensity at regular intervals (on Mondays, Wednesday and Fridays) in addition to regular 20-min morning training. Control group subjects performed two 90-min training units of moderate intensity twice a week (on Mondays and Thursdays) in addition to regular morning training. They underwent regular kinesiologic program designed for their particular units. During the treatment, all three groups of draftees had one conditioning full-pack 15-km march, according to the training program. Control group draftees performed training in cutter rowing once a week as part of naval education.

Study subjects underwent a battery of 13 motor tests for assessment of explosive strength, repetitive strength, anaerobic capacity and aerobic endurance on two occasions at a 9-week interval.

As recruit training in the Croatian Army is greatly based on their capabilities in terms of endurance and strength, the variables chosen in this study will best present the efficiency of specially designed treatments performed as part of specialist training in Croatian Navy draftees.

The following tests were used for explosive strength assessment:

LJS = long jump from the spot;
HJS = high jump from the spot;
TBS = throwing bomb from the spot.

The following tests were used for repetitive strength assessment:

OHB = overgrasp on the horizontal bar;
PUG = pushups from the ground;
FTB = forward trunk bending;
DNB = deep knee-bends.

The following tests were used for anaerobic capacity (sprint) assessment:

S60 = 60-m sprint from high start;
S100 = 100-m sprint from high start;
S200 = 200-m sprint from high start.

The following tests were used for aerobic endurance assessment:

R1500 = 1500-m run;
R3200 = 3200-m run;
M10000 = 10000-m full-pack march.

The structural or qualitative differences in time function[17] were obtained by rotated factor solutions, LSDIF analysis (tests of differences between correlation matrixes of two time points), and QDIFF1 analysis (determining measures of local changes based on the relative norm of the matrix of the expected covariances after treatment)[18,19]. Differences between time points were processed by univariate analysis for dependent samples, multivariate analysis of variance (MANOVA), and multivariate discriminative analysis of dependent samples (SSDIF)[3,20].

Results

Structural transformation in time function of some strength and endurance factors in naval draftees (submitted to differently designed kinesiologic treatments) were analyzed by use of varimax factors (obtained by rotation of the main components of intercorrelation matrix), LSDIF analysis and QDIFF1 (Tables 1–3). For additional explanation of the structural changes observed, results on quantitative changes (partial changes and structure of discriminative function of changes for each group of subjects) are also presented (Table 4).

In experimental group 1 (Table 1), on the first measurement, the first varimax factor was defined by markedly high projections of the variables of anaerobic and aerobic endurance. This factor defines general running ability. The second varimax factor was predominantly defined by high projections of the variables for assessment of upper extremity and trunk repetitive strength, followed by aerobic endurance. The third varimax factor was mostly defined by explosive strength, followed by moderate projections of anaerobic capacity.

On the second measurement, the treatment had obviously produced structural changes (LSDIF analysis). The first varimax factor was predominantly defined, with almost maximal projections, by repetitive strength of upper extremities that was positively followed by moderate projections of other repetitive strength variables, sprint variables, and aerobic endurance variables. The second latent dimension was predominantly defined by explosive strength variables of the jump type and anaerobic capacity (60-m and

TABLE 1
VARIMAX FACTORS (V1, V2, V3) ON THE 1st AND 2nd MEASUREMENTS (M1, M2) AND THE ANALYSIS OF STRUCTURAL CHANGES IN EXPERIMENTAL GROUP 1

Variables	M1			M2			Local changes
	V1	V2	V3	V1	V2	V3	
LJS	– 0.31	0.25	0.78	– 0.16	– 0.86	– 0.26	0.05
HJS	– 0.27	0.18	0.83	– 0.16	– 0.89	– 0.17	0.07
TBS	– 0.03	0.14	0.68	0.24	– 0.39	– 0.55	0.12
DHB	– 0.24	0.74	0.27	– 0.80	– 0.27	– 0.09	0.05
PUG	– 0.10	0.86	0.16	– 0.90	– 0.16	– 0.10	0.11
FTB	– 0.14	0.81	0.14	– 0.52	– 0.17	– 0.50	0.23
DNB	– 0.77	0.23	0.01	– 0.48	– 0.21	– 0.52	0.10
S60	0.71	0.25	– 0.45	0.50	0.72	0.20	0.21
S100	0.76	0.08	– 0.49	0.42	0.73	0.33	0.14
S200	0.63	– 0.30	– 0.24	0.38	0.54	0.58	0.17
R1500	0.65	– 0.52	– 0.08	0.50	0.32	0.64	0.08
R3200	0.70	– 0.49	– 0.10	0.55	0.30	0.54	0.18
M10000	0.69	– 0.21	– 0.18	0.15	0.11	0.80	0.16
LSDIF – analysis							
Real matrix trace of the square of differences					= 3.48		
χ^2 (of functions of trace)					= 177.58		
Degrees of freedom					= 13		
Probability					= 0.00		

100-m sprint). The third latent dimension was defined by the variables for assessment of aerobic endurance, positively followed by repetitive strength of the trunk and lower extremities.

In experimental group 2 (Table 2), the first latent dimension was dominantly defined by explosive strength variables, positively followed by upper extremity repetitive strength and anaerobic capacity. Thus defined dimension was predominantly based on the predominance of the intensity of energy mobilization. The second dimension was defined by high projections of the variables for assessment of aerobic and anaerobic endurance, whereas the third latent dimension was predominantly defined by high projections of the variables for repetitive strength assessment.

On the second measurement, the treatment entailed structural changes in terms of homogenization of the motor functional abilities assessed. The first latent dimension was predominantly defined by high projections of the variables for aerobic endurance assessment and repetitive strength variables, which were positively and with moderate projections followed by the variables for anaerobic capacity assessment. This latent dimension was the major feature in this group of subjects.

The second latent dimension was defined by quite high projections of the variables for explosive strength assessment,

TABLE 2
VARIMAX FACTORS (V1, V2, V3) ON THE 1st AND 2nd MEASUREMENTS (M1, M2) AND THE ANALYSIS OF STRUCTURAL CHANGES IN EXPERIMENTAL GROUP 2

Variables	M1			M2		Local changes
	V1	V2	V3	V1		
LJS	– 0.85	0.30	0.10	– 0.26	0.88	0.05
HJS	– 0.76	0.27	0.14	– 0.23	0.83	0.01
TBS	– 0.76	0.18	0.00	– 0.26	0.88	0.03
DHB	– 0.55	0.20	0.63	– 0.55	0.54	0.02
PUG	– 0.48	0.27	0.68	– 0.64	0.49	0.09
FTB	– 0.10	0.12	0.74	– 0.65	0.12	0.11
DNB	0.20	0.34	0.61	– 0.64	0.02	0.06
S60	0.57	– 0.57	– 0.30	0.45	– 0.71	0.09
S100	0.46	– 0.63	– 0.32	0.56	– 0.67	0.05
S200	0.35	– 0.77	– 0.09	0.57	– 0.52	0.10
R1500	0.09	– 0.81	– 0.35	0.81	– 0.30	0.05
R3200	0.29	– 0.78	– 0.16	0.75	– 0.38	0.08
M10000	0.28	– 0.78	– 0.22	0.75	– 0.41	0.03
Probability						

LSDIF – analysis	
Real matrix trace of the square of differences	= 0.76
χ^2 (of functions of trace)	= 36.94
Degrees of freedom	= 13
Probability	= 0.00

TABLE 3
VARIMAX FACTORS (V1, V2, V3) ON THE 1st AND 2nd MEASUREMENTS (M1, M2) AND THE ANALYSIS OF STRUCTURAL CHANGES IN CONTROL GROUP

Variables	M1			M2			Local changes
	V1	V2	V3	V1	V2	V3	
LJS	– 0.39	0.05	0.74	0.72	0.11	– 0.38	0.02
HJS	– 0.38	– 0.06	0.72	0.69	– 0.01	– 0.40	0.02
TBS	– 0.38	– 0.25	0.34	0.37	– 0.27	– 0.43	0.03
DHB	– 0.17	– 0.20	0.82	0.86	– 0.12	– 0.17	0.07
PUG	– 0.03	– 0.25	0.76	0.84	– 0.09	– 0.11	0.12
FTB	– 0.38	– 0.42	0.23	0.45	– 0.29	– 0.35	0.16
DNB	0.14	– 0.63	0.33	0.46	– 0.45	0.11	0.12
S60	0.79	0.02	– 0.24	– 0.26	– 0.01	0.75	0.06
S100	0.86	0.07	– 0.21	– 0.18	0.02	0.88	0.04
S200	0.85	0.24	– 0.12	– 0.13	0.14	0.89	0.12
R1500	0.03	0.77	– 0.04	– 0.09	0.80	0.00	0.04
R3200	0.33	0.75	– 0.14	– 0.09	0.82	0.24	0.08
M10000	0.20	0.86	0.00	– 0.09	0.82	0.12	0.11
LSDIF – analysis							
Real matrix trace of the square of differences					= 1.09		
χ^2 (of functions of trace)					= 58.69		
Degrees of freedom					= 13		
Probability					= 0.00		

and less high projections of anaerobic capacity. In the experimental group 2, the treatment applied obviously tended to optimizing the recruits' energy functioning *via* two regulatory mechanisms, i.e. one responsible for the regulation of intensity of energy mobilization, and the other responsible for regulation of duration of energy mobilization.

In the control group (Table 3), on the first measurement the first latent dimension was dominantly defined by the variables of anaerobic capacity, followed by moderate projections of the explosive strength variables. The second latent dimension was defined by quite high projections of aerobic endurance variables, followed by moderate projections of the variables of lower extremity and trunk repetitive strength. The third latent dimension was predominantly defined by high projections of the variables of upper extremity repetitive strength and variables of jump-type explosive strength.

On the second measurement, the importance of dimensions in the overall motor efficiency was modified. So, the first factor defined by high projections of repetitive strength, especially of upper extremities, and variables of run-type explosive strength, accounted for most of total variability recorded in this group of subjects. The second latent dimension was defined by high projections of aerobic endurance, whereas the third was defined by markedly high projections of anaerobic capacity, followed by moderate

TABLE 4
PARTIAL DIFFERENCES OF MOTOR VARIABLES (F) AND THE STRUCTURE OF DISCRIMINANT FUNCION (DF) OF THE DIFFERENCES BETWEEN MEASUREMENT 2 AND 1 (M2 – M1) IN EACH GROUP

Variables	Experimental group 1 (N = 102)		Experimental group 2 (N = 97)		Control group (N = 108)	
	F	DF	F	DF	F	DF
LJS	111.86 ^{c}	0.26	90.59 ^{c}	0.26	0.37	– 0.14
HJS	33.70 ^{c}	0.14	93.65 ^{c}	0.27	0.13	– 0.22
TBS	120.43 ^{c}	0.27	148.03 ^{c}	0.34	0.46	– 0.13
DHB	338.41 ^{c}	0.45	308.18 ^{c}	0.49	3.00	– 0.21
PUG	482.35 ^{c}	0.53	345.64 ^{c}	0.52	0.40	0.13
FTB	361.73 ^{c}	0.46	243.80 ^{c}	0.43	0.17	0.24
DNB	208.41 ^{c}	0.35	158.77 ^{c}	0.35	0.13	– 0.61
S60	97.74 ^{c}	– 0.24	91.54 ^{c}	– 0.27	0.90	0.34
S100	131.43 ^{c}	– 0.28	123.69 ^{c}	– 0.31	0.15	0.14
S200	138.35 ^{c}	– 0.29	115.84 ^{c}	– 0.30	0.52	0.25
R1500	184.25 ^{c}	– 0.33	122.65 ^{c}	– 0.31	0.19	0.15
R3200	220.66 ^{c}	– 0.36	89.77 ^{c}	– 0.26	0.39	0.22
M10000	183.95 ^{c}	– 0.33	137.06 ^{c}	– 0.32	0.64	0.28

F = test of differences in variables;
^{c} $p < 0.001$

projections of the explosive strength variables.

Discussion

LSDIF analysis indicated significant structural changes in all groups of subjects. Most significant structural changes were observed in experimental group 1 consisting of naval draftees, and were less pronounced in experimental group 2. In the control group, the structural changes observed were considered to reflect differentiation and deviation from optimal relations between the variables, recorded on the initial measurement. This is also suggested by the results on quantitative changes (Table 4) that were mostly negative although statistically nonsignificant in the control group.

Local measures of changes show the extent to which each individual variable contributes to modifications in the dimension structure. In this context, it is evident that changes in the basic repetitive strength of the trunk, in anaerobic capacity and aerobic endurance were primarily responsible for the structural changes in experimental group 1. In the control group and to a lesser extent in experimental group 2, structural changes were mostly associated with changes in the repetitive strength of the trunk.

These results show the structural basis upon which quantitative changes induced by specially designed kinesiologic treatments reflect. Changes in some abilities will facilitate the others related to them to be attained. Thus, for example, changes in the repetitive strength of the trunk will facilitate performance of motor manifestations depending on the goal determinant including biomechanical and physiological patterns.

Partial differences in motor variables between the two measurements (F-tests), presented in Table 4, show that greatest quantitative changes in the two experimental groups occurred in the repetitive strength variables, more precisely, in the repetitive strength of upper extremities and trunk. High yet less pronounced changes occurred in aerobic endurance, followed by anaerobic capacity and explosive strength variables.

A more thorough insight into the changes can be obtained on the basis of structure of the discriminative function of the variables of differences between the measurements for each individual group of subjects.

It is evident that in the experimental groups, positive qualitative changes occurred in motor functioning as defined by the factors of strength and endurance assessed, because these changes also imply discriminative functions of changes, i.e. general development of repetitive strength, aerobic endurance, anaerobic capacity, and explosive strength. In the control group, an ability decrease (reduction) occurred, especially in the repetitive strength of lower extremities. These results indicate that the kinesiologic activity included in the Croatian Navy specialist training is inadequate for maintenance of the acquired level of motor capacities of the draftees.

The relationships of the variables used in the study changed between the first and second measurement in all groups of subjects, suggesting that qualitative changes had occurred. In the two experimental groups, the treatments generally resulted in higher correlation of repetitive strength variables with aerobic and anaerobic endurance by increasing general motor efficiency of the naval draftees.

Despite experimental group specificities, homogenization of repetitive strength and aerobic endurance into a single dimension responsible for the duration of maximal energy mobilization, and homogenization of explosive strength and anaerobic capacity into a single dimension responsible for the intensity of maximal energy mobilization are clearly observed.

In the control group of subjects, the treatment with inadequate kinesiologic load results in differentiation of capabilities, i.e. of repetitive strength, aerobic endurance and anaerobic capacity, into individual dimensions.

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UTJECAJ PROGRAMIRANIH KINEZIOLOŠKIH TRETMANA NA STRUKTURALNE TRANSFORMACIJE NEKIH MANIFESTACIJA SNAGE I IZDRŽLJIVOSTI ROČNIH VOJNIKA HRVATSKE VOJSKE

S A Ž E T A K

Strukturalne tj. kvalitativne promjene nekih motoričkih dimenzija (snage i izdržljivosti) za dvomjesečno razdoblje analizirane su na uzorku od 307 ispitanika muškog spola ročnih vojnika – mornara prosječne starosti 21 godinu. Ukupni uzorak ispitanika podijeljen je u 3 skupine: 1. eksperimentalnu (N = 102), 2. eksperimentalnu (N = 97) i kontrolnu skupinu (N = 108) koje su podvrgnute različitim kineziološkim tretmanima. Strukture izoliranih dimenzija nad 13 motoričkih varijabli u dvjema vremenskim točkama (dvaju tranzitivnih stanja) značajno su se promijenile kod sve tri skupine ispitanika. Tretmani u eksperimentalnim skupinama su utjecali na najveću povezanost repetitivne snage sa aerobnom izdržljivosti tako da u drugoj vremenskoj točki prva dimenzija upravo integrira te sposobnosti. Druga dimenzija integrira eksplozivnu snagu i anaerobni kapacitet, dok treća dimenzija kod prve eksperimentalne skupine integrira repetitivnu snagu trupa i nogu i aerobnu izdržljivost. Kod kontrolne skupine ispitanika su repetitivna snaga, aerobna izdržljivost i anaerobni kapacitet izolirane kao posebne dimenzije.