Musculoskeletal system disorders and dysfunctions in academic physical education service: mathematical model for kinesiological correction and progress forecast

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Abstract

Objective of the study was to offer a mathematical model for the students' musculoskeletal disorders correction service complementary to the physical education process.

Methods and structure of the study. Our study was designed to rate severity of the musculoskeletal disorders and dysfunctions in the context of the controllable education service factors – both exogenous and endogenous. The endogenous factors were assumed as controllable by the physical education / training system management with prudent timing and intensity of the training process, and efficient training and rehabilitation tools; and the endogenous ones controllable by the customizable kinesiological methods to effectively mitigate the dorsal disorders and pains. We used the test data correlation analysis to select arguments for a mathematical model for the dorsal discomfort and pains correction service forecast.

We sampled for the mathematical model testing experiment the 1-2-year students (n=300) of Omsk State Technical University majoring in physical education and sports and complaining about dorsal/ spinal discomfort and pains. The sample included 270 sporting students trained in the elective basketball, volleyball, powerlifting and swimming groups (n=60 each), plus a special health group (SHG, n=60).

Results and conclusion. The new mathematical model for the students' musculoskeletal disorders / dorsal discomfort and pains correction applicable in the physical education process makes it possible to complement the physical education curricula with customizable elective-sport-specific kinesiological methods. The progress test data generated by the mathematical model provides a basis for the individual musculoskeletal disorders / dorsal discomfort and pains correction forecasts to attain progress in the key controlled factors (X1 - X11), for effective mitigation of the symptoms. The mathematical model testing experiment showed the following progress variation zones in the sample: 61-70% (low); 71-75% (moderate); and 76-78% (high).

Keywords: *students, musculoskeletal disorder, dysfunction, dorsal discomfort and pains, mathematical forecast, physical education.*

Background. Presently the national health statistics rank musculoskeletal disorders in the student population second after cardiovascular pathologies due to many factors dominated by the innate musculoskeletal malformations and underdevelopments plus inefficiencies in the physical education service applied for the musculoskeletal disorder correction purposes [3, 11]. Analyses of the relevant research literature demonstrate growth in the student population complaining dorsal and spinal discomforts and pains. These health issues are clearly due to the academic education service with its mental/ emotional stressors and physical inactivity with the traditional sitting in classes in fixed postures – particularly stressful for the shoulder girdle muscles and spine. These and other aspects may be ranked among the educational health risk factors of special potential negative effects on the musculoskeletal system associated with the dorsal and spinal discomforts and pains [5, 7]. It should be mentioned that sporting young population is more exposed to the above health risks due to their musculoskeletal systems being under "double pressure" from both the academic classes and athletic training systems [6, 8].

Health disorders with the above symptoms are normally corrected by a set of traditional clinical physical therapy methods including massage, manual therapy, physiotherapy, acupuncture, etc. [2, 4], although these services are not always accessible and affordable for the sporting and unsporting students due to time limitations, financial constraints, etc. This is the key reason why the academic communities report a growing demand for do-it-yourself musculoskeletal disorders correction and health improvement methods as complementary to a reasonable physical activity for good health, quality of life and healthy lifestyle to counter the academic education related health risks. Presently a special priority in this context is given to the behavioral control approach geared to reduce the students' exposure to the health risks on the whole and musculoskeletal disorders / dorsal discomfort and pains risks in particular. Ideally such approaches should include individual kinesiological toolkits applicable as complementary to the academic education and athletic training processes.

Objective of the study was to offer a mathematical model for the students' musculoskeletal disorders correction service complementary to the physical education process.

Methods and structure of the study. Healthy lifestyles in the student communities will be encouraged by the pedagogical positions (role models) of the faculties with the progress facilitating provisions (institutional, logistical, moral and humanistic), and with a special contribution of modern kinesiological methods in the regular and self-reliant extracurricular theoretical and practical physical education / health activity.

Of special promise in the above health policies and practices are modern mathematical models applicable to diagnose and rate dorsal disorders and pains in student groups, with a special attention to the sporting ones [1, 9, 10]. Our study was designed to rate severity of the musculoskeletal disorders and dysfunctions in the context of the controllable education service factors – both exogenous and endogenous. The endogenous factors were assumed as controllable by the physical education / training system management with prudent timing and intensity of the training process, and efficient training and rehabilitation tools; and the endogenous ones controllable by the customizable kinesiological methods to effectively mitigate the dorsal disorders and pains. We used the test data correlation analysis to select arguments for a mathematical model for the dorsal discomfort and pains correction service forecast.

We sampled for the mathematical model testing experiment the 1-2-year students (n=300) of Omsk State Technical University majoring in physical education and sports and complaining about dorsal/ spinal discomfort and pains. The sample included 270 sporting students trained in the elective basketball, volleyball, powerlifting and swimming groups (n=60 each), plus a special health group (SHG, n=60).

Results and discussion. Given in Table 1 hereunder are the controllable factors (X1-X11).

A mathematical analysis to find the key controllable factors for the pain ranking index calculation gave us the means to produce a set of the following sport-specific progress forecast equations for the basketball, volleyball, swimming and powerlifting groups and SHG (Table 2):

Basketball: $y = 79{,}951 - 9{,}398 \cdot F_1 - 2{,}532 \cdot F_2$;

Volleyball: $y = 87{,}\ 535 - 7{,}074 \cdot F_1$;

Swimming: $y = 51{,}153 - 6{,}953 \cdot F_1$;

Powerlifting: $y = 34{,}682 - 5{,}738 \cdot F_1 + 2{,}325 \cdot F_3$,

and Special Health Group: $y = 58{,}039 - 4{,}016 \cdot F_1$,

Table 1. Controllable test rates

Anthropometric characteristics, functionality and physical fitness test rates	Weights
Body mass index, BMI	X_1
Deadlift strength, DS	X_2
Static endurance of the dorsal muscles, SEDM	X_3
Static endurance of the abs, SEA	X_4
Mobility of the cervical spine, MCS	X_5
Mobility of the lumbar spine, MLS	X_6
Standing long jump, SLJ	X_7
Pull-ups, PU	X_8
100m sprint, 100S	X_9
2000m race, 2000R	X_{10}
12-min walk/ run Cooper test, CT	X_{11}

Table 2. Controllable musculoskeletal disorders correction factors

Test rates	Weight	Basketball			Volleyball		Swimming			Powerlifting				SHG	
		F_1	F_2	F_3	F_1	F_2	F_1	F_2	F_3	F_1	F_2	F_3	F_4	F_1	F_2
BMI	X_1	-	0,683	-		0,748	-	-	0,906		0,805				-0,612
DS	X_2	0,829	-	-	0,668	-	0,717	-	-			0,892		0,543	-
SEDM	X_3	0,741	-	-	0,917	-	0,747	-	-	0,843	-	-	-	0,884	-
SEA	X_4	-	0,688	-	0,926	-	0,890	-	-	0,844	-	-	-	0,877	-
MCS	X_5	0,760	-	-	0,828	-	0,752	-	-	-	0,782	-	-		0,685
MLS	X_6	-	-	0,901	-0,943	-	-0,899	-	-		-0,707	-	-		-0,637
SLJ		-	0,776	-	-	0,690	-	0,833		0,810	-	-	-	0,820	-
PU	X_8	-	0,838	-	0,725	-	0,666	-	-	-	-	0,762	-	0,716	-
100S	X_9	0,758	-	-	-0,808	-	-	-	0,678	-	-		0,876		
2000R	X_{10}	-	-	-0,652	-0,669	-	-	0,630	-	-	-	-	0,645	-	-
CT	X_{11}	-	-	-	-	-	-	-	-	-	-	-	-	-	0,707
Variation %		32,9	25,7	16,3	57,14	12,46	48,19	17,40	12,16	33,96	19,77	13,17	10,72	45,85	15,38
Pain ranking index, %		69,3	18,7	12	89	11	87	13	-	66,3	6,9	26,8	-	78	22
Progress forecast zone variations		74,9% medium			69,6% low		77,75% high			77,63% high				61,23% low	

Note: X_1 is the body mass index (BMI); X_2 is the deadlift strength (DS); X_3 is the static endurance of the dorsal muscles (SEDM); X_4 is the static endurance of the abs (SEA); X_5 is the mobility of the cervical spine (MCS); X_6 is the mobility of the lumbar spine (MLS); X_7 is the standing long jump (SLJ); X_8 is the pull-ups (PU); X_9 is the 100m sprint (100S); X_{10} is the 2000m race (2000R); and X_{11} is the 12-min walk/ run Cooper test (CT).

where y means the pain ranking index, and F_1, F_2, F_3 are the key controllable factors based on analysis of the key variables $X_1 - X_{11}$.

The above analysis of key controllable factors using the mathematical model method makes it possible to individualize and customize the dorsal discomfort and pains correction service in every physical education / sport group to effectively mitigate the pain ranking index using the accessible kinesiological methods to restore the muscular tones and functions, with a special role played by a prudent physical training process management service.

Conclusion. The new mathematical model for the students' musculoskeletal disorders / dorsal discomfort and pains correction applicable in the physical education process makes it possible to complement the physical education curricula with customizable elective-sport-specific kinesiological methods. The progress test data generated by the mathematical model provides a basis for the individual musculoskeletal disorders / dorsal discomfort and pains correction forecasts to attain progress in the key controlled factors (X1 - X11), for effective mitigation of the symptoms. The mathematical model testing experiment showed the following progress variation zones in the sample: 61-70% (low); 71-75% (moderate); and 76-78% (high).

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