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CONTENTS

ORIGINAL ARTICLE

An analysis of the relationship between critical velocity and anaerobic speed reserve with match running profile in football

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The aim of this study was to analyse the relationship between critical velocity (CV) and anaerobic speed reserve (ASR) with match running profile in football.

Material and Methods The research group consisted of fifteen young male football players (n=15, age=16.60±0.51 years, height=177.40±5.25 cm, weight=67.20±5.52 kg, body mass index=21.32±0.96 kg/m^2). Yo-Yo intermittent recovery level 1 test (Yo-Yo IRT) was performed to determine maximal aerobic speed (MAS). Maximal sprint speed (MSS) was determined by 30-meter sprint test. CV and ADC parameters were obtained by linear regression model (Lin-TD: linear total distance model) between the covered distance and running duration in 800-meter and 2400-meter running tests. A 90-minutes football match was played to determine the subjects' match running profile (covered distance in every running category), which was examined by means of a global positioning system (GPS) device in five running categories (walking: 0-6.9 km/h, low intensity running: 7-12.9 km/h, middle intensity running: 13-17.9 km/h, high intensity running: 18-20.9 km/h, sprint: >21 km/h). Correlation analysis and multiple linear regression analysis was employed to analyse the collected data.

Results It was found that CV was significantly and positively correlated with total running distance as well as low and middle intensity running ($p<0.05$). A significant and negative correlation was found between ASR and all match running profiles ($p<0.05$). Both CV and ASR were significant predictors of high intensity running, maximum running speed and total running distance during match ($p<0.05$). However, while CV was a significant predictor of sprint running, ASR significantly predicted walking ($p<0.05$).

Conclusions Consequently, it may be concluded that in football, aerobic fitness is positively correlated to CV and negatively to ASR.

Keywords: anaerobic speed reserve, critical velocity, football running profile.

Introduction

Football is a sports branch that involves a wide range of different physical activities such as jumping, tackles, walking, change of direction and backward running. The activities required during a football match are predominantly low intensity activities [1]. The repeated and intermittent exercises during a football match necessitate aerobic fitness and high recovery capacity [2]. Football players are required to have high aerobic endurance for successful match performance. The players' energy requirement during match is met by their aerobic energy metabolism to a substantial extent (90%) [3]. Also, high aerobic fitness provides faster recovery after anaerobic exercises through the effective use of aerobic energy pathways [4]. Football players cover considerable distance with a range of physical activities during match. It was indicated that players playing in European elite football teams covered 10.7-12 km distance during match [5], which means that football matches involve activities that require aerobic fitness due to match length [6]. Yet, high intensity and sprint running are at least as important as they determine match performance. It was reported that football matches involved high intensity activities inducing lactate accumulation [6]. The removal of lactate from blood is important for endurance, while aerobic fitness supports the players in terms of high repeated sprint performance. Therefore, the determination of match running profile may be helpful in determining appropriate physical exercises for shorter recovery periods through increased lactate tolerance.

One parameter of aerobic endurance is critical velocity (CV). CV refers to the highest exercise intensity that can theoretically be sustained without fatigue in a prolonged exercise [7, 8, 9]. Maximum oxygen uptake (VO_{2max}) is reached gradually once CV is surpassed, and CV represents the lower exercise limit that stimulates VO_{2max} [10, 11]. CV is defined as an indicator of aerobic fitness level. CV is determined by linear regression analysis between the covered distance and running duration. According to the linear regression model, the slope of regression line is defined as CV, and the interception on y-axis of the line represents the anaerobic distance capacity

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(ADC) [12]. ADC is the limited anaerobic energy source of the muscles, and it is indicated that any given distance is covered according to this reserve [13]. CV is a simple indicator of aerobic fitness level in athletes. It was indicated that marathon running time was related to the CV parameter [13]. Marathon running is an exercise that requires high aerobic endurance, which is confirmative of the relationship between CV and aerobic fitness. Considering that football is a sports branch requiring high aerobic endurance, CV may serve as a useful performance parameter, and hence be a helpful tool to determine aerobic exercise intensity in football.

One of the anaerobic parameters is anaerobic speed reserve (ASR). The lowest speed at which maximum oxygen consumption occurs is known as maximum aerobic speed (MAS) [14, 15, 16], and ASR is the difference between MAS and maximal sprint speed (MSS) [17, 18]. It was indicated that ASR could be used to predict performance in high intensity exercises [17, 18]. ASR may be used as an alternative performance evaluation parameter to anaerobic power tests [19]. It was determined that the lower the ASR value, the better the repeated sprint performance [20]. This finding showed that the aerobic energy metabolism supported resistance against fatigue in athletes with lower ASR. Football players must show high tolerance to fatigue during match. Therefore, aerobic energy metabolism is a key factor for football players. Determining the relationship between ASR and match running profile (walking, low and high intensity running, and sprint) can therefore be a useful tool for coaches and sports scientists. CV, ADC and ASR parameters can be helpful in measuring and monitoring the aerobic and anaerobic fitness levels of players, and hence, be used as a baseline when planning the most adequate exercises with a view to achieve improved aerobic and anaerobic fitness levels in football players. The aim of this study was to examine the effects of CV, ADC and ASR parameters on match running profile.

Material and Methods

Participants

The research group consisted of fifteen young male football players (n=15, age=16,60±0,51 years, height=177,40±5,25 cm, weight=67,20±5,52 kg, body mass index=21,32±0,96 kg/m^2), who were attending regular training sessions in the young team of a professional football team competing in the Turkish Super League. The research procedure was explained to subjects in detail. The subjects filled informed consent forms and participated in the study voluntarily. The research was performed in accordance with the principles of the Helsinki Declaration.

Research Design

Data Collection

All tests were performed two days apart. The tests were conducted in the same hour of the day to prevent the effects of biological rhythm on physical performance. The effect of environmental conditions and pitch ground was minimized by performing all of the tests on natural grass football pitch and in sunny weather conditions. A warm-up period of 10 minutes was applied before all tests. The procedure applied during tests is explained below.

Maximal Aerobic Speed Test

The players' maximal aerobic speed values were determined by Yo-Yo intermittent recovery level 1 test (Yo-Yo IRT), which was conducted on natural grass football pitch. The 25-meter test track consisted of a 5-meter recovery zone and a 20-meter running zone (Figure 1).

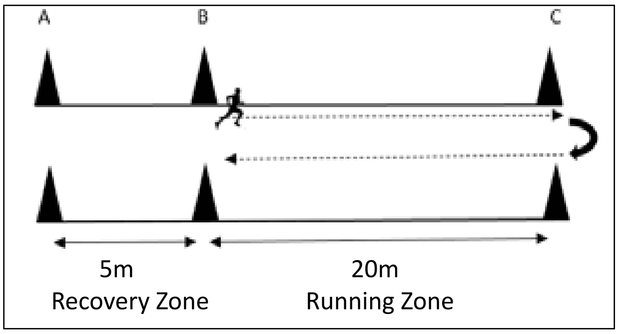

Figure 1. Yo-Yo Intermittent Recovery Level 1 Test Track.

The players began running in the 20-meter zone in time to a beep sound emitted from a loudspeaker connected to a computer. Players tried to reach the start and end of the 20-meter zone by the time the next beep was emitted each time. Subsequent to every out and back shuttle (40-meters) in the 20-meter running zone, the players performed 10-meter low intensity running (2x5-meter running with turning) in the 5-meter recovery zone until the next beep. Yo-Yo IRT was commenced at 10 km/h speed. The test was started, and players covered 160 meters (4x40 meters) at 10-13 km/h and then 280 meters (7x40 meters) at 13.5-14 km/h speed. After that, running speed was gradually increased by 0.5 km/h every 320 meters (8x40 meters) until end of the test. The test was terminated when a player failed to complete a successful shuttle in the allocated time twice consecutively or ended the test voluntarily. The final speed of test was recorded as maximal aerobic speed (MAS). Also, the distance covered in the test was recorded to test form. The maximum oxygen uptake (VO_{2max}) values in the test were determined by the formula below [21]:

$$VO_{2max}\ (ml/kg/min) = \text{Covered distance in Yo-Yo IRT (m)} \times 0.0084 + 36.4$$

Sprint Tests

30-meter sprint test was performed to determine maximal sprint speed (MSS). A 30-meter sprint track was established on natural grass football pitch. Sprint time was measured by wireless photocell system (Witty, Microgate, Bolzano, Italy) that comprised three gates, which were put up at the start, 10-meter, and finish points of the test, respectively (Figure 2).

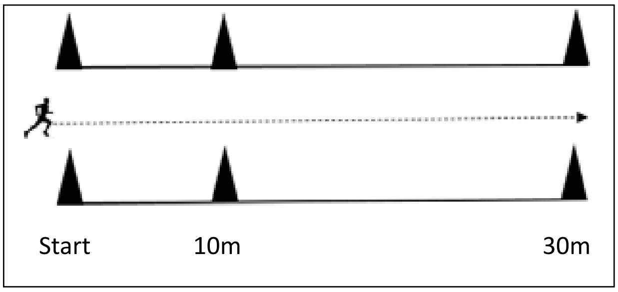

Figure 2. Sprint Test Track

After warm-up exercises, the players performed a one-time sprint run to get used to the test. The photocell system automatically started when the players passed the start gate of the device. The players did their sprint run with maximal speed, accompanied by verbal encouragement. The photocell device automatically stopped when player passed the fourth gate. The 0-10- (sprint time between start and 10-meter), 10-30- (interval sprint time between 10- and 30-meter) and 0–30-meter sprint time (sprint time between start and 30-meter) of players were recorded in seconds by the device software. The test was performed twice, and the best sprint time was accepted as test score. The speed values of 0-10-, 10-30- and 0–30-meter sprint was calculated in km/h using the speed=distance/time formula on Excel (Microsoft Excel, Microsoft Office 365, Redmond, WA, USA). The speed value of the best 10-30-meter sprint running was determined as maximal sprint speed (MSS) [19].

Anaerobic Speed Reserve

Anaerobic speed reserve (ASR) is defined as the indicator of a-lactic anaerobic sprint performance [19]. ASR was determined by the formula below [18]:

Anaerobic speed reserve (km/h) = Maximal sprint speed (km/h) – Maximal aerobic speed (km/h)

Critical Velocity Tests

Critical velocity (CV) and anaerobic distance capacity (ADC) were determined by 800- and 2400-meter maximal running tests [22]. The players performed the 800 and 2400-meter running test on natural grass football pitch. The 800 and 2400-meter running tracks were measured and marked with training cones. The tests were performed two days apart in the same hour of the day and in sunny weather conditions. After warm-up exercises, players performed the running tests with maximal effort. Verbal encouragement was given to players by trainers. 800- and 2400-meter running times were measured by a professional hand stopwatch in seconds (Casio HS-80TW-1DF, Casio Computer Ltd, Tokyo, Japan). The running times were recorded to test form. CV and ADC parameters were determined using 800 and 2400-meter running distance and running times by Linear Total Distance Model (Lin-TD), which employed the linear regression formula shown below and consisted of a linear regression analysis between the distances covered and running times on the 800- and 2400-meter tracks [8, 12, 13, 23, 24, 25, 26, 27, 28, 29, 30]:

Running distance (D) = ADC + CV x Running time (t)

Match Running Profile

A football match was played on natural grass pitch with regular dimensions in 11v11 format. The running profile during match was determined by global positioning system (GPS) receivers transferring data at a frequency of 10 Hertz (GPSsport EVO, GPSsport, Canberra, Australia). GPS system software was installed on a notebook. The running profile during match was divided into five categories as shown in Table 1 [31]. GPS receivers determined the mean, maximum, and total running distance parameters. The match running profile (covered distance in every running category) was automatically recorded by software of the GPS system. The players wore GPS vests, with GPS receivers put into the pockets of the vests. The young football players performed a warm-up exercise period before match. The GPS receivers commenced recording the running profile when the match started. The football match lasted for two equal halves according to official rules. The running data of players who played the entire match (90 minutes) were included in analysis.

Table 1. Match Running Profile Parameters [31]

Match Running Profile Categories	Running Speed Intervals (km/h)
Walking	0-6.9 km/h
Low intensity running	7-12.9 km/h
Middle intensity running	13-17.9 km/h
High intensity running	18-20.9 km/h
Sprint running	>21 km/h

Statistical Analysis

The SPSS statistic package program was used for all analysis (SPSS Version 20.0, IBM Corporation, Armonk, New York, USA). All data was presented in descriptive values (mean, standard deviation, minimum, maximum values). Suitability to normal data distribution was examined by a Shapiro-Wilks test. The relationship between match running profile with other test parameters was determined by Pearson and Spearman correlation coefficients. Multiple linear regression analysis was used to determine the effects of test parameters on match running profile parameters. The linear regression models consisted of one dependent (match running profile parameters) and three independent variables (CV, ADC and ASR). The collinearity between independent variables was examined by VIF (variance inflation factor) coefficients and tolerance values. The significance value in all analysis was established as p<0.05.

Results

According to mean values of the tests (Table 2), it was found that the longest distance covered by young football players during match was with middle intensity running (13-17,9 km/h). Also, the players spent the most time at 188-220 beat/min heart rate interval during match. The mean maximum oxygen uptake values of players were found as 53,39 ml/kg/min during Yo-Yo IRT.

The correlation between match running profile

Table 2. Physical Characteristics and Test Parameters of Young Football Players (n=15)

Parameters		Mean ($\bar{x}$)	Standard Deviation (SD)	Min.	Max.
Physical Characteristics	Age (years)	16.60	0.51	16.00	17.00
	Height (cm)	177.40	5.25	166.00	185.00
	Weight (kg)	67.20	5.52	58.00	80.00
	Body mass index (kg/m^2)	21.32	0.96	19.69	23.37
Match Running Profile	Walking (0-6.9 km/h)	489.33	93.51	325.00	645.00
	Low intensity running (7-12.9 km/h)	635.27	109.22	489.00	878.00
	Middle intensity running (13-17.9 km/h)	1081.00	259.54	713.00	1482.00
	High intensity running (18-20.9 km/h)	77.93	120.06	0.00	400.00
	Sprint running (>21 km/h)	2.47	8.04	0.00	31.00
	Mean running speed (km/h)	8.34	0.52	7.20	9.10
	Maximum running speed (km/h)	19.50	1.28	16.90	22.30
	Total running distance (m)	2288.40	482.40	1642.00	3416.00
Match Heart Rate Profile	Time spent between 0-120 beat/min (sec)	36.60	103.47	0.00	394.00
	Time spent between 121-144 beat/min (sec)	23.20	16.72	0.00	53.00
	Time spent between 145-164 beat/min (sec)	65.73	49.11	10.00	190.00
	Time spent between 165-176 beat/min (sec)	149.87	139.40	28.00	561.00
	Time spent between 177-188 beat/min (sec)	327.93	162.71	85.00	637.00
	Time spent between 188-220 beat/min (sec)	381.93	264.71	0.00	828.00
	Mean heart rate (beat/min)	181.80	6.53	172.00	194.00
	Maximum heart rate (beat/min)	196.73	6.54	184.00	210.00
	% Heart rate (% of maximum heart rate)	90.73	3.20	86.00	97.00
Test Parameters	Critical velocity (km/h)	14.43	0.93	13.58	17.04
	Anaerobic distance capacity (m)	115.52	37.94	45.78	185.20
	Anaerobic speed reserve (km/h)	11.32	1.27	8.67	13.27
	Yo-Yo IRT VO_{2max} (ml/kg/min)	53.39	3.63	48.50	62.27
	Yo-Yo IRT final speed (km/h)	16.73	0.70	16.00	18.50
	Yo-Yo IRT distance (m)	2022.67	431.73	1440.00	3080.00
	800 meter running time (sec)	172.40	10.70	151.00	194.00
	2400 meter running time (sec)	572.87	28.02	489.00	604.00
	10-meter sprint time (sec)	1.77	0.04	1.69	1.84
	10-meter sprint speed (km/h)	20.33	0.49	19.57	21.30
	30-meter sprint time (sec)	4.34	0.10	4.20	4.47
	30-meter sprint speed (km/h)	24.89	0.58	24.16	25.71
	20-meter (between10-30-meter) sprint time (sec)	2.57	0.07	2.46	2.70
	20-meter (between10-30-meter) sprint speed (km/h) (MSS)	28.05	0.82	26.67	29.27

Min.: Minimum, Max.: Maximum, MSS: Maximal sprint speed parameters and test results is presented in Table 3. CV was found to be significantly correlated with total running distance, low and middle intensity running ($p<0.05$). There was no significant correlation between match running profile parameters and ADC ($p>0.05$). However, ASR was significantly correlated with all match running profile parameters except for mean running speed ($p<0.05$). In terms of other test parameters, it was found that Yo-Yo IRT results were correlated with match running profile parameters except for mean running speed ($p<0.01$). 800-meter running time was significantly correlated with maximum running speed, high intensity and sprint running ($p<0.05$). Furthermore, it was found that 2400-meter running time was significantly correlated with low and middle intensity running, maximum running speed, and total running distance ($p<0.05$).

The test results' effect on match running profile parameters is presented in Table 4. According to the variance explanation proportion of multiple regression models, CV, ADC, and ASR explained the variance on maximum running speed at the highest rate (R^2=0,829, $p<0.05$). It was determined that ADC was the most effective parameter on maximum running speed according to standardized Beta coefficients of the regression model (β=0,609, $p<0.05$). Also, all-independent variables (CV, ADC and ASR) had significant effect on high intensity running (β=0,743, 0,575, -0,387, $p<0.05$, respectively). All parameters explained variance on high intensity running with 74,6% (R^2 = 0,746, $p<0.05$). However, it was found that CV was the most effective parameter on high intensity running (β=0,743, $p<0.05$) and sprint running (β=0,824, $p<0.05$). Along with that, CV and ASR parameters explained variance on total

Table 3. Correlation Coefficients between Match Running Profile and Test Parameters (n=15)

Test Parameters	Match Running Profile							
	Walking (0-6.9 km/h)	**Low intensity running (7-12.9 km/h)**	**Middle intensity running (13-17.9 km/h)**	**High intensity running (18-20.9 km/h)**	**Sprint running (>21 km/h)**	**Mean running speed (km/h)**	**Maximum running speed (km/h)**	**Total running distance (m)**
CV (km/h)	0.225	0.572*	0.580*	0.063	0.380	0.259	0.394	0.634*
ADC (m)	0.234	-0.209	-0.114	0.132	-0.161	-0.194	0.289	-0.032
ASR (km/h)	-0.644**	-0.632*	-0.583*	-0.669**	-0.643**	-0.038	-0.773**	-0.758**
Yo-Yo IRT VO_{2max} (ml/kg/min)	0.828**	0.733**	0.791**	0.804**	0.721**	0.012	0.842**	0.964**
Yo-Yo IRT final speed (km/h)	0.809**	0.744**	0.715**	0.751**	0.589*	-0.027	0.850**	0.931**
Yo-Yo IRT distance (m)	0.828**	0.734**	0.791**	0.804**	0.721**	0.012	0.842**	0.964**
800 meter running time (sec)	-0.351	-0.288	-0.247	-0.689**	-0.598*	0.012	-0.622*	-0.448
2400 meter running time (sec)	-0.296	-0.577*	-0.580*	-0.329	-0.465	-0.223	-0.541*	-0.688**
10-meter sprint time (sec)	-0.163	0.063	-0.028	0.276	0.298	0.180	0.019	0.041
10-meter sprint speed (km/h)	0.166	-0.063	0.036	-0.277	-0.296	-0.175	-0.020	-0.036
30-meter sprint time (sec)	0.156	0.274	0.201	0.353	0.389	0.134	0.359	0.294
30-meter sprint speed (km/h)	-0.154	-0.277	-0.196	-0.347	-0.385	-0.131	-0.353	-0.290
20-meter sprint time (sec)	0.301	0.333	0.286	0.321	0.357	0.079	0.472	0.373
20-meter sprint speed (km/h)	-0.305	-0.342	-0.290	-0.316	-0.354	-0.082	-0.470	-0.377

*p<0.05, **p<0.01, CV: critical velocity, ADC: anaerobic distance capacity, ASR: anaerobic speed reserve

Table 4. Multiple Linear Regression Analysis Results Regarding the Effects of Critical Velocity, Anaerobic Distance Capacity and Anaerobic Speed Reserve on Match Running Profile

Dependent Variable	Predictor Variables	B	β	p	R^2
Walking (0-6.9 km/h)	constant	510.976		0.420	0.500
	CV	23.275	0.232	0.455	
	ADC	0.927	0.376	0.201	
	ASR	-41.050	-0.558	0.041†	
	*F=3.667. **p<0.05				
	Model: walking = 510.976 + 23.275 x CV + 0.927 x ADC - 41.050 x ASR				
Low intensity running (7-12.9 km/h)	**Predictor Variables**	**B**	**β**	**p**	**R^2**
	constant	384.474		0.590	0.527
	CV	48.360	0.413	0.185	
	ADC	0.112	0.039	0.887	
	ASR	-40.653	-0.473	0.069	
	*F=4.088. **p<0.05				
	Model: low intensity running = 384.474 + 48.360 x CV + 0.112 x ADC - 40.653 x ASR				
Middle intensity running (13-17.9 km/h)	**Predictor Variables**	**B**	**β**	**p**	**R^2**
	constant	-581.931		0.732	0.520
	CV	160.603	0.577	0.076	
	ADC	1.574	0.230	0.414	
	ASR	-73.949	-0.362	0.155	
	*F= 3.967. **p<0.05				
	Model: middle intensity running = -581.931 + 160.603 x CV + 1.574 x ADC – 73.949 x ASR				
High intensity running (18-20.9 km/h)	**Predictor Variables**	**B**	**β**	**p**	**R^2**
	constant	-1099.778		0.074	0.746
	CV	95.727	0.743	0.005†	
	ADC	1.818	0.575	0.014†	
	ASR	-36.579	-0.387	0.046†	
	*F=10.771. **p<0.05				
	Model: high intensity running = -1099.778 + 95.727 x CV + 1.818 x ADC – 36.579 x ASR				
Sprint running (>21 km/h)	**Predictor Variables**	**B**	**β**	**p**	**R^2**
	constant	-84.808		0.033†	0.781
	CV	7.113	0.824	0.002†	
	ADC	0.070	0.329	0.100	
	ASR	-2.072	-0.328	0.066	
	*F=13.046. **p<0.05				
	Model: sprint running = -84.808 + 7.113 x CV + 0.070 x ADC – 2.072 x ASR				
Mean running speed (km/h)	**Predictor Variables**	**B**	**β**	**p**	**R^2**
	constant	6.049		0.215	0.072
	CV	0.143	0.258	0.541	
	ADC	-0.001	-0.042	0.913	
	ASR	0.025	0.062	0.853	
	*F=0.286. **p>0.05				
	Model: mean running speed = 6.049 + 0.143 x CV – 0.001 x ADC + 0.025 x ASR				

Table 4. (continued).

Dependent Variable	Predictor Variables	B	*β*	p	R^2
	Predictor Variables	**B**	***β***	**p**	**R^2**
Maximum running speed (km/h)	constant	13.071		0.022†	0.829
	CV	0.734	0.533	0.011†	
	ADC	0.021	0.609	0.003†	
	ASR	-0.578	-0.573	0.002†	
	*F=17.838. **p<0.05				
	Model: maximum running speed = 13.071 + 0.734 x CV + 0.021 x ADC – 0.578 x ASR				
	Predictor Variables	**B**	***β***	**p**	**R^2**
Total running distance (m)	constant	-863.987		0.682	0.787
	CV	334.617	0.646	0.007□	
	ADC	4.514	0.355	0.075	
	ASR	-194.254	-0.512	0.008□	
	*F=13.557 . **p<0.05				
	Model: total running distance = -863.987 + 334.617 x CV + 4.514 x ADC – 194.254 x ASR				

† - p<0,05, * Coefficient of regression model, ** significance value of regression model, CV: critical velocity, ADC: anaerobic distance capacity, ASR: anaerobic speed reference.

running distance with 78,7% (R^2=0,787, p<0.05) in the regression model. It was seen that CV was the most effective parameter on total running distance (β=0,646, p<0.05). The independent variables (CV, ADC, and ASR) had no significant effect on mean running speed, low and middle intensity running parameters although the regression models were statistically significant (p>0.05).

Discussion

The research results showed that CV was significantly correlated with total running distance, low and middle intensity running in football match (Table 3). In contrast, ADC was not significantly correlated with match running profile parameters (Table 3). ASR was negatively correlated with all match running parameters except for mean running speed (Table 3). Multiple regression analysis demonstrated that the CV, ADC, and ASR parameters were significant predictors of high intensity running and maximum running speed parameters in football match (Table 4). Furthermore, CV was predictive of sprint running and total running distance while ASR had significant effect on walking and total running distance (Table 4).

In a study by Aquino et al., a positive correlation was found between Yo-Yo IRT total distance and medium intensity running (8.1-13.0 km/h) in football match [32]. In our study, Yo-Yo IRT distance was found to be positively correlated with low intensity running (7-12.9 km/h). Moreover, our study confirmed a moderately positive relationship between CV and low and high intensity running. These findings support the results found by Aquino et al. [32]. Both researches were conducted on young football players. Hence, the similarity between the findings of the two researches may be attributable to similarity of the sample groups. Moreover, Yo-Yo IRT total distance was positively related to high intensity running (13-18 km/h). Likewise, total activities (sum of sprint (>18 km/h) and high intensity running) was positively related to total distance covered in football match [33]. High intensity and sprint running were found to be related to Yo-Yo IRT distance in our study. According to the findings of the present research, it was also found that CV was a predictor of high intensity running, sprint, and total distance in football match. CV is an aerobic fitness parameter, and this relationship is similar to the Yo-Yo IRT performance-match performance relationship. These findings show that football match performance is related to aerobic performance tests like Yo-Yo IRT.

It was found that the repeated anaerobic sprint test parameters (mean and total test time, mean and total sprint speed, minimum, mean and maximum power, fatigue index) of amateur football players were significantly correlated with ADC and 800-m running test (running time, mean and maximum running speed) parameters [34]. This showed that ADC was effective on repeated sprint performance. On the other hand, both the ADC parameter of the Lin-TD model and the CV parameter of the linear velocity model, which is the other linear regression model used for determination of CV and ADC, were found to be significantly correlated with Yo-Yo IRT VO_{2max} and distance values in young football players [35]. It may be said that Yo-Yo IRT test performance depends on aerobic endurance to a significant extent. Since aerobic fitness is a supporter of anaerobic capacity, it can be stated that ADC may accompany the CV-Yo-Yo IRT relationship. A study by Ari demonstrated that the CV values of young football players were positively correlated with their medium intensity running numbers, the distance covered with medium intensity running (medium intensity running: 13-17.9 km/h) and total covered distance during football match [36]. The relationship found between CV and middle intensity running and total running distance supports the findings of the mentioned study. These findings indicated that CV was an indicator of aerobic performance in football.

Redkva et al. found that Yo-Yo IRT distance values were significantly correlated with the total covered distance, high intensity activity and sprint numbers during football match [37]. Our findings were similar to the results of that study. In our study, all match running parameters were found to be significantly correlated to the Yo-Yo IRT distance value except for mean running speed. All findings indicated that Yo-Yo IRT was a valid field test in football. Hence, running performance in football players may be tracked by their Yo-Yo IRT performance.

ASR was significantly correlated with the match running profile except for mean running speed in our study. In a study by Ortiz et al., it was shown that ASR was significantly correlated with the MAS and MSS values of football players [38]. Similar to ASR, Yo-Yo IRT parameters were found to be closely related to match running profile parameters in our study. It was observed that there was a parallelism between ASR and Yo-Yo IRT. The MAS parameter is usually determined by aerobic endurance tests such as Yo-Yo IRT. In our study, Yo-Yo IRT performance as an indicator of MAS was positively related to match running profile parameters while there was a negative correlation between ASR and match running profile. The negative correlation between match running profile parameters and ASR revealed that the aerobic effect on match performance was high. The difference in ASR is reportedly attributable to the difference in MAS values [39]. The ASR values of athletes may be different although their MAS values are same. This difference is due to the MSS value. The ASR value of athletes with higher MSS is higher than those with low MSS, although their MAS values are same. Therefore, athletes with higher MSS may perform exercises with a lower ASR percentage compared to athletes with lower MSS in the same exercise intensity [39]. Anaerobic activities such as sprint are frequently performed during the match. However, in football, the contribution of the aerobic system to performance is higher than the anaerobic metabolism. Higher aerobic fitness also means faster recovery and ability to perform more high intensity activities.

High intensity activities are of high importance for football teams. It was determined that successful teams performed more high intensity activities than unsuccessful teams when they had the ball in possession during the match [40]. CV was the best predictor of total covered distance, high intensity and sprint running in the current study. According to these findings, it may be said that high aerobic fitness level is related with the ability to recover quickly between high-intensity activities. However, ASR had negative effect on aerobic activities such as walking and total covered distance. This result may show that the aerobic contribution to exercise is lower in athletes with high ASR. The aerobic contribution level is a key factor for faster recovery between high intensity activities in football. High repeated sprint performance is closely related to higher recovery capability. Furthermore, it was found that ADC was the best predictor of high intensity running and maximum running speed in our study. It may be concluded that ADC is closely related with high intensity runs as an anaerobic fitness parameter in football.

Conclusion

Consequently, the CV parameter is an indicator of aerobic performance during match. The ASR parameter represents a reserve between MAS and MSS values and is dependent on MAS level. Higher MAS value means higher aerobic endurance and more aerobic contribution to exercise. It may be said that ASR is negatively related to aerobic contribution to exercises during match. The statistical values indicate that ASR was negatively related to maximum running speed at the highest proportion during football match. The results obtained in our study indicated that the higher the ASR value, the lower the aerobic fitness level. It might therefore be stated that the level of aerobic endurance during a football match is positively related to CV and negatively related to ASR. It is recommended that football coaches make use of CV and ASR parameters when determining the intensity of aerobic endurance exercises.

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Conflict of interest

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ORIGINAL ARTICLE

Housework-based exercise versus conventional exercise on health-related fitness of adolescent learners

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim There is a void in the literature comparing the fitness effects of housework-based exercise (HBE) and conventional exercise (CE), including studies that adapt housework into an exercise program. This study examines the effectiveness of HBE and CE on adolescent learners' health-related fitness (HRF) and compares the effectiveness of the two exercises.

Material and Methods This study uses a parallel-group, randomized controlled trial with 120 adolescent learners; 60 are in the HBE group, and 60 are in the CE group. The participants in the HBE group exercised using housework activities, while the participants in the CE group exercised by doing push and pull, squats, lunges, leaps and jumps, planks, etc. The participants in both groups trained for at least an hour every weekday for 12 weeks under the supervision of qualified fitness instructors.

Results The findings show that HBE improves the fitness levels of adolescent learners, albeit it has no significant improvement in their BMI. Furthermore, HBE significantly improves the cardiorespiratory fitness of females more than males. Finally, CE outperforms the HBE in producing more significant and favorable fitness effects.

Conclusions When planned, implemented, and monitored carefully as an exercise program, doing housework is just as good as doing traditional exercise for keeping or improving adolescent learners' fitness. Furthermore, the findings indicate that HBE may be more appropriate for females because it involves household-related tasks that they traditionally perform.However, CE produces more positive and significant fitness effects. Thus, teachers can use HBE in the remote exercise activities of their learners along with CE.

Keywords: adolescent, conventional exercise, fitness, housework-based exercise, randomized controlled trial

Introduction

Since 2012, physical inactivity has been viewed as a pandemic [1], with 28% of the world's population, or around 1.4 billion people, remaining inactive [2]. Physical inactivity is rising, particularly among adolescents [3, 4, 5, 6]. Along with the rise of sedentary behavior [7], this problem has become a significant risk factor for noncommunicable diseases [8, 9, 10], and it is responsible for 9% of premature deaths, chronic disability, and a significant economic burden. Before the COVID-19 pandemic [2, 11, 12] reported that 1 in 3 adults and 3 in 4 adolescents worldwide did not meet the guidelines for physical activity. This figure appears to have gotten worse with the pandemic, following the closure of several businesses and schools as well as the strict implementation of social isolation measures at home [13, 14]. Many studies have shown that sedentary habits or a reduction in physical activity can impact a person's overall fitness level, including the reduction of muscular strength, agility, and flexibility, poor cardiorespiratory endurance, and body composition [15, 16,17]. Hence, it is crucial to take action to remain active and continue to enhance personal fitness and health despite being isolated at home.

For people to remain active, engaging in various movement practices is crucial [18]. It needs a solid personal decision and deliberate action to be active and healthy. There are limitless ways to be physically active. To avoid confusion about what physical activities to do, a person can choose between active participation in conventional exercises (CE) and more participation in daily physical activities like housework-based exercises (HBE) or household activities. By "conventional exercises", it means the basic exercise movements of push and pull, squats, lunges, leaps and jumps, planks, etcetera, done through body weight management or exercise equipment. CE has many benefits, and some of them improve health-related fitness (HRF) factors like body mass index (BMI), cardiovascular endurance, flexibility, and muscular strength and endurance [19, 20, 21, 22, 23]. CE also lowers the risk of heart disease, helps control blood sugar and insulin, helps people stop smoking, improves mental health and mood, and sharpens skills like thinking, learning, and making decisions [24]. Other researchers have said that it increases walking speed, gait, and physical activity while reducing pain, improving

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range of motion and connective tissue flexibility, and reducing functional restrictions [25].

On the other hand, to encourage individuals to have at least some physical activity, the focus has changed from structured forms of exercise to lifestyle activities that may be incorporated into one's typical daily routines [26]. Cleaning the floor, cleaning windows, doors, and walls, moving furniture, getting water, doing laundry, washing dishes, climbing stairs, and other household activities all require physical effort; hence, calorie burn from these movements adds up. According to [27], non-exercise activity thermogenesis, or the energy expenditure from activities other than structured sports and exercises, can add up to 2000 kcal of extra energy consumed over the basal metabolic rate. Likewise, [28] found that lifestyle activities, like taking the stairs, when done actively, may have a similar impact on various health outcomes to sustained, structured exercise. This idea suggests that if planned, implemented, and monitored carefully as an exercise program, doing housework is just as good as doing traditional exercise for keeping or improving fitness. It is interesting to research the subject of HBE's fitness advantages because previous studies have found that these activities, as well as work and transportation activities, have only marginal health advantages compared to CE [29, 30]. However, most of these studies did not conduct an intervention approach that compared the two exercises, making it difficult to establish causality and comparability. Additionally, while there are studies linking housework activities to certain aspects of fitness [29, 31, 32] and a small number of studies associating housework exercises with psychological variables [33], there is a void in the literature that adapts housework into an exercise program for fitness. Furthermore, it is essential to stay active by engaging in HBE since it is inexpensive, reasonably safe, and widely accepted by the general public.

Regular physical activity is essential for maintaining health during quarantine [34, 35]. The house served as the hub of activities during this pandemic [36], and the researchers believe that people must exercise, whether conventionally or housework-based. In addition, the pandemic offers either threats or opportunities to people. Taking it as a threat would escalate physical inactivity and psychological distress [37], worsening the already ill-fated situations of many. Using it as an opportunity would lead to new ways of doing things and, more importantly, would get more people moving, especially adolescents whose physical activity is affected by excessive Internet gaming [38] and social media use [39]. When HBE is coupled with a must-take academic subject like physical education (PE), there is still an opportunity to remain physically active. As the remote learning of PE takes place, learners can take advantage of this, especially since it has learning tasks and assignments that the curriculum framers and teachers carefully design to keep them active while staying at home [40, 41]. These include using CE and HBE as part of learners' performance tasks. However, one can wonder if HBE and CE give the same or different fitness benefits when both are structured, conducted, and monitored carefully.

Purpose of the Study. This study examined the effectiveness of HBE and CE on adolescent learners' health-related fitness (HRF) and compared the effectiveness of the two exercises. The results of this undertaking can provide empirical support for PE learning resource decision-making and put HBE as one of the deliberate interventions in the teaching-learning process for PE subjects.

Materials and Methods

Participants.

The selected population sample underwent several screening procedures to ensure the health and safety of the study. The first screening was based on age (a minimum of 18 years old and a maximum of 19) to ensure that the exercise training program would be developmentally appropriate. The second screening dealt with health and comorbidity status, as those with health or medical-related concerns were excluded. The third screening involved assessing exercise readiness using the Physical Activity Readiness Questionnaire. 170 participants were initially screened, with 45 excluded based on the criteria and five declining their participation due to personal concerns. Overall, the screening procedures resulted in 120 fit and healthy participants in the study, and they were randomly assigned into two groups; the experimental group (HBE) (n=60: male = 30; female = 30) and the control group (CE) (n=60: male = 30; female = 30). The randomization was done at a 1:1 ratio using an online software research randomizer.

Research Design.

This parallel-group, randomized controlled trial examined the effectiveness of HBE and CE on adolescent learners' health-related fitness (HRF) and compared the effectiveness of the two exercises. The intervention began in January 2022 and ended in July 2022. The first two months were allocated for the approval of consent forms, the conduct of orientation, and the start of physical conditioning of the participants. The subsequent months were devoted to the conduct and monitoring of the study's intervention as well as the analysis of results. Accordingly, the study's exercise trainers, research assistants, and participants were blinded to the study's hypothesis. The participants in the HBE group conducted their exercises using housework activities. On the other hand, the participants in the CE group did basic exercises like push-ups, pull-ups, squats, lunges, leaps and jumps, and planks. Participants in both groups work out for at least an hour each weekday for 12 weeks under the supervision of qualified fitness instructors.

Measurement and Implementation Procedures. The Department of Education's Revised Fitness Test Manual [42] was utilized to examine the participants' HRF. This document is a national guide for all Filipino teachers who give physical fitness tests to their students [43]. It instructs teachers on conducting, monitoring, and understanding the results of different fitness tests. The Department of Education has constantly been monitoring and reviewing the manual; hence, the results and interpretations are consistent with the national standard for physical fitness.

Monitoring Procedures for Exercise Program Adherence. At least two methods were used to monitor participants' adherence to the exercise programs: (1) requiring the participants to complete a daily training log detailing the completion and proper execution of the exercise; at the end of the log, both the participants and their parents or guardians were required to affix their signature to confirm the accuracy of the remarks made therein; and (2) participants were required to submit unedited and uncut video recordings of their exercise once a week for the monitoring of researchers and fitness instructors. All participants faithfully adhered to the monitoring mechanisms, as indicated by their regular and 100% submissions of their daily training log and video recordings. There was no incidence of injury reported in the study.

Statistical Analysis.

Microsoft Excel was used to encode, analyze, and store all the data. The significant difference between the pre-test and post-test mean scores of each training program was examined using the t-test for paired samples. The mean gain scores of the two training programs were also analyzed using the t-test for independent samples. Cohen's d was used to measure the t-test effect size with the following interpretation: .2 small, .5 medium, and .8 large [44, 45]. The threshold for statistical significance was set at $p < 0.01$.

Results

The baseline HRF components of the participants were examined, and no significant differences were found between the HBE and CE groups, regardless of gender (Table 1). Additionally, it can be inferred from the mean scores of the HBE and CE groups that the participants in both groups either have a normal, good, or average level of fitness in all HRF components [42].

On the other hand, the findings in Table 2 show the effects of the CE on the HRF of participants. The male and female groups significantly improved all HRF components, as can be gleaned from the increase in mean scores from pre-test to post-test, significant p-value scores, and large effect sizes.

Another notable finding is reported in Table 3,

Table 1. Significant difference of the Pre-test scores of participants (male vs. male, female vs. female) in the HBE and CE groups

HRF components	Groups	HBE		CE		t	P	Remarks
		Mean	SD	Mean	SD			
Body Mass Index (BMI)	Male	22.46	0.85	22.39	0.74	0.34	0.74	Not sig
	Female	22.46	0.75	22.88	0.72	-2.16	0.03	Not sig
Cardiovascular Endurance	Male	85.23	1.70	84.47	2.10	1.56	0.12	Not sig
	Female	85.90	1.03	85.97	0.85	-0.27	0.79	Not sig
Flexibility of the Left Arm	Male	2.26	0.20	2.18	0.17	1.67	0.10	Not sig
	Female	2.23	0.16	2.14	0.18	2.04	0.05	Not sig
Flexibility of the Right Arm	Male	2.28	0.24	2.20	0.15	1.41	0.16	Not sig
	Female	2.23	0.25	2.25	0.30	-0.23	0.82	Not sig
Flexibility of the Left Leg	Male	32.20	1.06	31.57	1.50	1.89	0.06	Not sig
	Female	32.40	1.57	32.97	1.40	-1.48	0.15	Not sig
Flexibility of the Right Leg	Male	33.37	1.67	32.50	2.08	1.78	0.08	Not sig
	Female	32.80	2.09	33.47	1.41	-1.45	0.15	Not sig
Muscle Strength and Endurance of the Arms	Male	18.30	0.84	18.13	0.63	0.87	0.39	Not sig
	Female	17.97	0.72	17.90	0.71	0.36	0.72	Not sig
Muscle Strength and Endurance of the Core	Male	32.50	1.38	31.83	0.65	2.46	0.02	Not sig
	Female	31.70	1.06	32.03	0.93	-1.30	0.20	Not sig

α=0.01

Table 2. Significant difference of the Pre- test and post-test scores of participants (male vs. male, female vs. female) in the CE group

HRF Components	Pre-test		Post-test		Paired t test			
	Mean	SD	Mean	SD	t	P	Cohen's d	Remarks
Males (N = 30)								
BMI	22.39	0.74	21.51	1.03	4.27	<.01	0.98	Sig
Cardiovascular Endurance	84.47	2.10	81.50	1.11	7.32	<.01	1.77	Sig
Flexibility of the Left Arm	2.18	0.17	2.83	0.26	-11.21	<.01	2.96	Sig
Flexibility of the Right Arm	2.20	0.15	2.87	0.29	-13.34	<.01	2.91	Sig
Flexibility of the Left Leg	31.57	1.50	37.30	2.78	-14.10	<.01	2.53	Sig
Flexibility of the Right Leg	32.50	2.08	37.70	2.78	-10.72	<.01	2.10	Sig
Muscle Strength and Endurance of the Arms	18.13	0.63	23.43	3.95	-7.00	<.01	1.86	Sig
Muscle Strength and Endurance of the Core	31.83	0.65	36.80	3.52	-7.28	<.01	1.93	Sig
Females (N = 30)								
BMI	22.88	0.72	21.30	0.80	9.72	<.01	2.08	Sig
Cardiovascular Endurance	85.97	0.85	82.10	1.90	10.10	<.01	2.63	Sig
Flexibility of the Left Arm	2.14	0.18	2.79	0.32	-9.09	<.01	2.50	Sig
Flexibility of the Right Arm	2.25	0.30	2.80	0.30	-8.45	<.01	1.83	Sig
Flexibility of the Left Leg	32.97	1.40	37.07	2.53	-6.69	<.01	2.01	Sig
Flexibility of the Right Leg	33.47	1.41	37.67	3.79	-4.88	<.01	1.47	Sig
Muscle Strength and Endurance of the Arms	17.90	0.71	24.60	2.85	-13.38	<.01	3.23	Sig
Muscle Strength and Endurance of the Core	32.03	0.93	36.70	3.64	-6.74	<.01	1.76	Sig

α=0.01

which shows the effects of the HBE on the HRF of participants. The most significant improvements in male HRF components are: flexibility of the left arm (from M = 2.26, SD = 0.20 to M = 2.48, SD = 0.17) with significant p-value and large effect size (p = <.01, Cohen's d =1.19); flexibility of the right arm (from M = 2.28, SD = 0.24 to M = 2.46, SD = 0.21) with significant p-value and large effect size (p = <.01, Cohen's d =0.80); muscle strength and endurance of the arms (from M = 18.30, SD = 0.84 to M = 20.77, SD = 2.94) with significant p-value and large effect size (p = <.01, Cohen's d =1.14); and muscle strength and endurance of the core (from M = 32.50, SD =1.38 to M = 33.27, SD = 1.72) with significant p-value and medium effect size (p = <.01, Cohen's d =0.5). The rest of the components have improved, albeit not significantly, as can be gleaned from the increase in mean scores from pre-test to post-test.

For females, all seven HRF components have improved (cardiovascular endurance, flexibility of the left arm, flexibility of the right arm, flexibility of the left leg, flexibility of the right leg, muscle strength and endurance of the arms, and muscle strength and endurance of the core) as can be gleaned from the mean scores from pre-test to post-test, as well as the p-value and effect size scores. The BMI score has improved from (M = 22.46, SD = 0.75) to (M = 22.35, SD = 0.80); albeit insignificant (p = 0.05, Cohen's d = 0.14).

Finally, Table 4 shows participants' significant mean gain differences (male vs. male, female vs. female) in the HBE and CE groups.

The CE program outperformed the HBE program, as observed in its higher mean gain scores in all HRF components. In particular, the males in CE showed the following positive improvements: cardiovascular endurance (M = -2.97, SD = 2.22) than HBE (M= -0.23, SD=0.73) with significant p-value and large effect size (p = <.01, Cohen's d =1.66); flexibility of the left arm (M = 0.65, SD = 0.32) than HBE (M =0.22, SD=0.25) with significant p-value and large effect size (p = <.01, Cohen's d =1.50); flexibility of the right arm (M=0.66, SD=0.27) than HBE (M=0.18, SD=0.26) with significant p-value and large effect size (p = <.01, Cohen's d =1.81); flexibility of the left leg (M=5.73, SD=2.23) than HBE (M=1.10, SD=2.37) with significant p-value and large effect size (p = <.01, Cohen's d =2.01); flexibility of the right leg (M=5.20, SD=2.66) than HBE (M=1.50, SD=3.08) with significant p-value and large effect size (p = <.01, Cohen's d =2.01); muscle strength and endurance of the arms (M=5.30, SD=4.15) than HBE (M=2.47,

Table 3. Significant difference of the Pre- test and post-test scores of participants (male vs. male, female vs. female) in the HBE group

HRF Components	Pre-test		Post-test		Paired t test			
	Mean	SD	Mean	SD	t	p	Cohen's d	Remarks
Males (N = 30)								
BMI	22.46	0.85	22.05	0.80	1.99	0.06	0.50	Not sig
Cardiovascular Endurance	85.23	1.70	85.00	1.53	1.76	0.09	0.14	Not sig
Flexibility of the Left Arm	2.26	0.20	2.48	0.17	-4.86	<.01	1.19	Sig
Flexibility of the Right Arm	2.28	0.24	2.46	0.21	-3.86	<.01	0.80	Sig
Flexibility of the Left Leg	32.20	1.06	33.30	2.37	-2.54	0.02	0.60	Not sig
Flexibility of the Right Leg	33.37	1.67	34.87	2.67	-2.67	>.01	0.67	Not sig
Muscle Strength and Endurance of the Arms	18.30	0.84	20.77	2.94	-4.37	<.01	1.14	Sig
Muscle Strength and Endurance of the Core	32.50	1.38	33.27	1.72	-2.89	<.01	0.50	Sig
Females (N = 30)								
BMI	22.46	0.75	22.35	0.80	2.06	0.05	0.14	Not sig
Cardiovascular Endurance	85.90	1.03	84.50	1.46	3.63	<.01	1.11	Sig
Flexibility of the Left Arm	2.23	0.16	2.37	0.23	-3.97	<.01	0.71	Sig
Flexibility of the Right Arm	2.23	0.25	2.41	0.19	-3.95	<.01	0.81	Sig
Flexibility of the Left Leg	32.40	1.57	33.27	2.10	-2.98	<.01	0.47	Sig
Flexibility of the Right Leg	32.80	2.09	34.97	2.33	-4.04	<.01	0.98	Sig
Muscle Strength and Endurance of the Arms	17.97	0.72	21.40	3.20	-5.26	<.01	1.48	Sig
Muscle Strength and Endurance of the Core	31.70	1.06	33.60	1.79	-4.69	<.01	1.29	Sig

α=0.01

SD=3.09) with significant p-value and medium effect size (p = <.01, Cohen's d =0.77); and muscle strength and endurance of the core (M=4.97, SD=3.74) than HBE (M=0.77, SD=1.45) with significant p-value and large effect size (p = <.01, Cohen's d =1.48). For the BMI component, although the findings indicated no significant difference in the two exercise programs with small effect size (p = 0.12, Cohen's d = 0.41), the mean gain scores showed that CE (M =-0.89, HBE = 1.14) has more improvement than HBE (M =-0.42, SD = 1.15).

On the other hand, the females in CE have significantly higher mean gain scores than the females in HBE in seven HRF components, and only the flexibility of the right leg component has no significant difference with the p = value of (0.05) with a medium effect size of (Cohen's d = 0.52); albeit still having a higher mean score than HBE (CE: M = 4.20, SD = 4.72 > HBE: M = 2.17, SD = 2.94).

Discussion

This study gives an in-depth look at how HBE and CE affect the HRF components of adolescent learners and how these effects compare to each other. Before the implementation of the HBE and CE, as shown in Table 1, it was made sure that there was no significant difference between the participants in terms of their level of fitness in BMI, cardiovascular endurance, flexibility, muscular endurance, and strength. This is to ensure that biases among the participants of each training program are eliminated and to allow better comparison between the two training programs. This, coupled with thorough and regular monitoring and validation mechanisms, enhances the study's robustness, reliability, and validity in the context of an exercise program.

Then, after 12 weeks of intervention, one notable finding of the study confirms that CE offers positive effects on various HRF components (Table 2), corroborating prior related studies [19, 20, 21, 22, 23]. It is widely known that closing public parks and fitness facilities has pushed individuals to stay at home, which has impeded their participation in physical activity, particularly among adolescents. Although adolescents have become less active during the pandemic due to several factors, such as excessive Internet gaming [38] and social media use [39], it is still possible to maintain a healthy fitness level with the aid of PE teachers who constantly provide their learners with opportunities to exercise. Hence, implementing and adapting CE remains one of the most important ways to help maintain and

Table 4. Significant mean gain difference of participants (male vs. male, female vs female) in the HBE and CE groups.

HRF Components	HBE		CE		Independent t test			
	Mean	SD	Mean	SD	t	p	Cohen's d	Remarks
Males								
BMI	-0.42	1.15	-0.89	1.14	1.58	0.12	0.41	Not sig
Cardiovascular Endurance	-0.23	0.73	-2.97	2.22	6.41	<.01	1.66	Sig
Flexibility of the Left Arm	0.22	0.25	0.65	0.32	-5.80	<.01	1.50	Sig
Flexibility of the Right Arm	0.18	0.26	0.66	0.27	-6.98	<.01	1.81	Sig
Flexibility of the Left Leg	1.10	2.37	5.73	2.23	-7.81	<.01	2.01	Sig
Flexibility of the Right Leg	1.50	3.08	5.20	2.66	-4.98	<.01	1.29	Sig
Muscle Strength and Endurance of the Arms	2.47	3.09	5.30	4.15	-3.05	<.01	0.77	Sig
Muscle Strength and Endurance of the Core	0.77	1.45	4.97	3.74	-5.74	<.01	1.48	Sig
Females								
BMI	-0.11	0.30	-1.58	0.89	8.53	<.01	2.21	Sig
Cardiovascular Endurance	-1.40	2.11	-3.87	2.10	4.54	<.01	1.17	Sig
Flexibility of the Left Arm	0.14	0.20	0.65	0.39	-6.34	<.01	1.65	Sig
Flexibility of the Right Arm	0.18	0.25	0.55	0.36	-4.68	<.01	1.19	Sig
Flexibility of the Left Leg	0.87	1.59	4.10	3.36	-4.77	<.01	1.23	Sig
Flexibility of the Right Leg	2.17	2.94	4.20	4.72	-2.00	0.05	0.52	Not sig
Muscle Strength and Endurance of the Arms	3.43	3.58	6.70	2.74	-3.97	<.01	1.03	Sig
Muscle Strength and Endurance of the Core	1.90	2.22	4.67	3.79	-3.45	<.01	0.89	Sig

α=0.01

enhance students' fitness in school or at home.

Another notable finding of this study shows that HBE has favorable effects on various HRF components (Table 3). This finding adds to earlier research that found a link between physical housework and fitness [29, 31, 32]. Also, it backs up the results of a study [28] that said active lifestyle activities (like climbing stairs) might have the same effect on various health outcomes as aerobic exercise. It also supports the study's results [46] that said housework might have the same effects as aerobic exercise because both activities raise the body's core temperature. Further, performing housework and caregiving activities are opportunities for increasing overall physical activity levels, especially for those with low financial and time resources [47]. Therefore, adapting housework into an exercise program is a beneficial starting point to improve one's fitness levels. Likewise, instilling in people the benefits of performing daily routines in their homes, particularly amid remote work and learning, is crucial to maintaining and enhancing fitness.

Furthermore, it is essential to remember that HBE should focus on the person's situation to get the best results. Since every person had a different scenario from the others, careful planning for each participant's household activities as a form of exercise is necessary. If there are no stairs in the home, comparable housework is offered, such as scrubbing the floor, with the time and intensity of exercise adjusted accordingly. Also, setting up regular monitoring and validation systems is vital because exercising at home is prone to inconsistent adherence to guidelines due to several factors that may come in the way, including the lack of an outside professional who can physically monitor and validate the exercise.

Another notable finding in Table 3 shows that the BMI levels of the male and female groups did not significantly improve, demonstrating that HBE does not affect body composition. This finding further supports prior studies that reported domestic-related activities do not have an association or have a negative association with BMI or leanness [26, 32, 48, 49]. One reason is that housework often requires isometric contractions and uses fewer muscle groups. This type of movement uses less energy and may not change BMI. In addition, the study participants before the intervention were in a normal range of BMI for both male and female groups. So, it is safe to say that CE has kept the participants' BMI scores in the normal range.

Table 3 also shows that the cardiorespiratory fitness scores of men and women are different, with women more likely to yield improvement than men. This difference in scores between men and women probably comes from the notion that women traditionally do more housework than men. Hence, they may have engaged the HBE more pedantically and intensely than men. This assumption has also been made in previous studies [26, 50]. Furthermore, the findings indicate that HBE may be more appropriate for females because it involves household-related tasks that they traditionally perform.

Finally, Table 4 shows that CE has higher positive effects than the HBE for both the male and female groups, as demonstrated by its higher mean gain scores in every HRF component. Such findings are consistent with previous research indicating that housework, career, and transportation activities have only marginal health benefits compared to CE [29, 30]. One explanation might be the structure of training activities in CE, which has a reputation for giving careful attention to each training component—frequency, intensity, duration, and type. Contrary to the HBE, which places generic emphasis on enhancing HRF components during tasks like mopping the floor, cleaning the windows, and washing the laundry, CE training exercises address specific HRF components. For instance, Pilates aims to increase flexibility, whereas plank exercises and crunches primarily work on the strength and endurance of the core muscles. Additionally, CE often has high-intensity movements of large muscle groups performed for brief intervals with at least 60% of maximal oxygen uptake. This movement improves heart rate, blood pressure, breathing, and energy expenditure. This, coupled with planned rest intervals and enough recovery, will improve long-term peripheral and metabolic activities, resulting in better health advantages and an improved fitness level [19, 20, 21, 22, 23, 51].

On the other hand, there were no significant differences in the post-test scores between HBE and CE for components like the BMI for males and the flexibility of the right leg for females. This finding shows that even though neither of the exercise programs led to significant changes, they successfully kept the participants' normal fitness levels in BMI and flexibility. Overall, this study adds to the evidence of previous studies, explaining that exercise, whether it is traditional or not, is a crucial way to stay fit and healthy while in quarantine [34, 35]. This concept is critical for adolescents who, due to various factors, including excessive Internet gaming and social media use, become less active during the pandemic [38, 39].

Conclusions

When planned, implemented, and monitored carefully as an exercise program, doing housework is just as good as doing traditional exercise for keeping or improving adolescent learners' fitness. However, CE produces more positive and significant fitness effects. Thus, teachers can use HBE in the remote exercise activities of their learners along with CE.

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Conflict of interest

There is no conflict of interest in the conduct of the research.

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ORIGINAL ARTICLE

The influence of jumping performance and coordination on the spike ability of young volleyball athletes

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Spike is the most important techniques to be mastered due to its big impacts to volleyball match. There is still lack of study to evaluate and discusses how the role of jumping performance and coordination in volleyball could affect spike ability. The purpose of this study was to determine the influence of these variables on spike ability.

Material and Methods This study used a quantitative descriptive method, involved 42 participants (20 men and 22 women). The jump performance was measured using MyJump 2 application which can measure flight time, force, jump height, jumping power and speed based on free-arm jumping method. Then, the measurement of coordination was done using an alternative hand wall test. Spike ability is shown by the results of the hit and spike performance. Spike performance was based on The Volleyball Test Skills for Smasher. For spike performance, data collection is based on observations from five phases of spike movement; i) Initial posture; ii) Initial Motion; iii) Motion of Appeal; iv) Advanced Motion; v) Placement of the ball, using the scoring points 1-4. All the data was analyzed using descriptive statistics and Pearson Correlation.

Results The results of the study show that in the perspective of gender differences, almost all variables had significant difference between men and women on flight time (0.028 < 0.05), force (0.001 < 0.01), jump height (0.040 < 0). 0.05), strength (0.001 < 0.01), and speed (0.028 < 0.05), coupled with coordination (0.003 < 0.01), hit results (0.181 > 0.05), and spike performance (0.216 > 0.05). Meanwhile, the relationship between variables were found to be significant (p-value < 0.01) on the five jumping performance variables. Another significant correlation obtained from the results of calculations between coordination and jump height (0.033 < 0.05), coordination with strength (0.044 < 0.05), coordination with spike hitting results was significant (0.003 < 0.01). Instead of them, relationship between one and another was not found significant relationship (p-value > 0.05).

Conclusions Coaches can use the information in this study as a guideline to develop training program to improve their athletes effectiveness in spiking.

Keywords: spike, volleyball, jumping, performance, coordination

Introduction

Volleyball consists of a variety of sprints, jumps (blocking and spiking), and high-intensity field movements that occur repeatedly during matches [1]. In volleyball, the spike technique has a significant impact on attack and match results [2]. Volleyball spike requires special skills with high coordination demands through several stages including running, countermovement jumps, a set of explosive overhead movements in the air, and landing phase [3]. The resulting stroke will be determined by the spike phases. It requires sharp analysis from coaches and sports analysts data so that the analysis evaluation is on target and has the potential to improve and improve the spike ability of young volleyball athletes based on their individual needs.

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Elementary errors can occur during jumping movements and arm-leg coordination. Due to a variety of factors, this is what causes the ball to slide out or touch the net during the attack. As a result, eye, arm, and leg coordination combine to produce a capable spike ability. The most important secret to teaching a beginner volleyball player to love the game is to stop teaching the underarm pass. Experts hope that no coaches or teachers repeat the statement that 'if you can't pass, you can't hit the ball'. When a new volleyball player is instructed to pass with their arms, they will go home and ask how to get rid of the pain in their arms after practicing, and the next day they will reconsider whether it is necessary to continue practicing because the training they do makes them sick. The first thing that needs to be altered is the method of teaching or training [4] when coaches and teachers intend to help new volleyball players develop their skills. In the process to develop the game, it should be started with ball hitting and over passing, then move on to the serve (which is controlled by the player and has arm action that allows even young players to send the ball over the net).

Other common mistakes during spikes include running to the ball then smash (Run Up) and jumping (Take Off) too quickly even though the ball has not been released by the feeder, causing the timing with the ball to be off [5]. The ball is then out of reach and has already made a punching motion, preventing hand contact with the ball [2]. Furthermore, there is no wrist flick when hitting the ball, so the ball does not dive into the field area. Finally, when landing, using the tip of the foot should be avoided as this increase vulnerability to injury [3]. Because all of the spike stages have not been solved one by one, there are still errors in the way of learning and the athlete's grasping power to apply physical work and techniques in the field, and many people are unaware of the significant role of jumps and spike coordination on performance and shot results.

Spike applies work in two ways: running while jumping spikes with one leg and two legs [6]. As a result, physical abilities must be supported during the volleyball match. According to one previous study, elite and non-elite volleyball athletes differ in muscle strength, arm muscle strength, and aerobic endurance [7]. In one study of female athletes, the key aspects for spike jump height were; i) optimization of exposure and energy conversion, ii) wide swing arm range allows for strong counter movements, with thus increased range of motion in the lower leg, and iii) large angular velocity in the ankle and knee, particularly on the dominant side [8]. Furthermore, elite volleyball athletes require pre-match training to improve and improve physical condition, which is supported by volleyball game techniques and strategies. Muscle strength and endurance, particularly in the upper and lower extremities, are essential for serving, passing, spiking, and blocking [7]. Over the last decade, the complexity of spike analysis has steadily increased, with practical implications for both coaches and athletes. Spike success is determined by physical [9] and psychological [10] characteristics that can be captured by a variety of kinematic variables of movement [2, 11] and ball speed after momentum of the hand hitting the ball [2].

The purpose of this study is to investigate the effects of jumping performance and eye-arm coordination on spike ability, which includes spike performance and hitting results. The findings of this study are hoped to assist coaches and athletes in evaluating their spike ability and correcting deficiencies so that each stage of the spike movement has a positive effect on the results of a shot that slides hard, is directed, and enters the opponent's area.

Materials and Methods

Participants.

Female and male adolescent athletes totalled 42 subjects in this study, with 20 males and 22 females were recruited based on voluntary basis. Table 1 showed the anthropometric characteristics of the participants. This study was approved by the Human Ethics Committee of Universitas Negeri Yogyakarta.

Table 1. Data of anthropometric characteristics of the participants

Anthropometric	Average SD
Height (cm)	170.83 9.23
Weight (kg)	62.31 10.22
BMI	21.285 2.59
Height when sitting(cm)	86.15 4.44
Lower Limb (cm)	40.76 2.68
Upper Limb (cm)	47.85 3.91
Leg (cm)	22.38 2.49
Length of the leg (cm)	111 6.51
Lower Arm (cm)	25.13 2.83
Upper Arm (cm)	29.88 3.51

Research Design.

To determine the relationship between the independent and dependent variables in the data analysis, this study employs a quantitative descriptive method with the use of correlation. The components of jumping performance and coordination to spike ability are the key data variables in this study (consisting of performance and hitting results).

Data Collection.

Jumping Performance. Data retrieval for jumping performance was performed using the MyJump 2 application [12], where the instrument is valid and reliable [13], and which can measure flight time, force, jump height, power, and velocity using the free arm jump method.

Coordination. Measurement of coordination data was performed using the alternate hand wall test.

Spike Ability. This study's spike ability is the result of spike blows. The Volleyball Test Skills for Smasher was used to collect data on spike performance. The assessment in previous studies was used to determine the target area of the hit result [14]. Participants were given the opportunity to hit five times in the IV position while performing spike movements. The ball is directed by the participants to a predetermined and desired target. Balls that enter target areas A, B, C, D, or go out of bounds are scored according to the scoring system in Table 2. If a player touches the net while spiking, the score is not recorded and the spike is repeated. The total score is the sum of the points earned from the five spike opportunities. Table 2 shows the measurement scoring of The Volleyball Test Skills for Smasher. Figure 1 also shows the assessment description when viewed from the perspective of the field image.

Table 2. Scoring system for Spike Skills Test

Target Area	Point
A	4
B	3
C	2
D	1
Beyond the area	0

Statistical Analysis

The data was processed using an independent t-test to determine gender differences in ability and a multi-correlation analysis to determine the magnitude of the relationship between jumping performance and coordination elements and spike ability. The data analysis results are expected to reveal which variables have the most powerful influence on the ability to spike between jumping performance and coordination, as well as the relationship between the four existing variables.

Results

Data analysis begins with a gender perspective, male and female, obtaining data on each component, where there are eight different components: Flight time, Force, jump height, power, velocity, coordination, spike results, and spike performance in Table 3. Except for results ($p = 0.181$, $p > 0.05$), almost all variables indicated a significant difference between men and women in the measurement variables of flight time ($p = 0.028$, $p < 0.05$), force ($p = 0.001$, $p < 0.01$), jump height ($p = 0.040$, $p < 0.05$), power ($p = 0.001$, $p < 0.01$), velocity ($p = 0.028$, $p < 0.05$), and coordination ($p = 0.003$, $p < 0.01$).

Table 3. Comparison of measurement component between men and women

Measurement Component	Sig.
Flight time	0.028*
Force	0.001**
Jump height	0.040*
Power	0.001**
Velocity	0.028*
Coordination	0.003**
Spike Ability	0.181

* significant correlation (p-value < 0.05); ** significant correlation (p-value < 0.01)

Table 4 showed that the relationship between variables appears to be significant (p-value > 0.01) on all five jumping performance variables. Another statistically significant correlation was found between coordination and jump height ($p = 0.033$, $p < 0.05$), coordination and power ($p = 0.044$, $p < 0.05$), and coordination with a significant spike shot ($p = 0.003$, $p < 0.01$). The remaining data on the relationship between one component and another was not found to be statistically significant (p-value > 0.05).

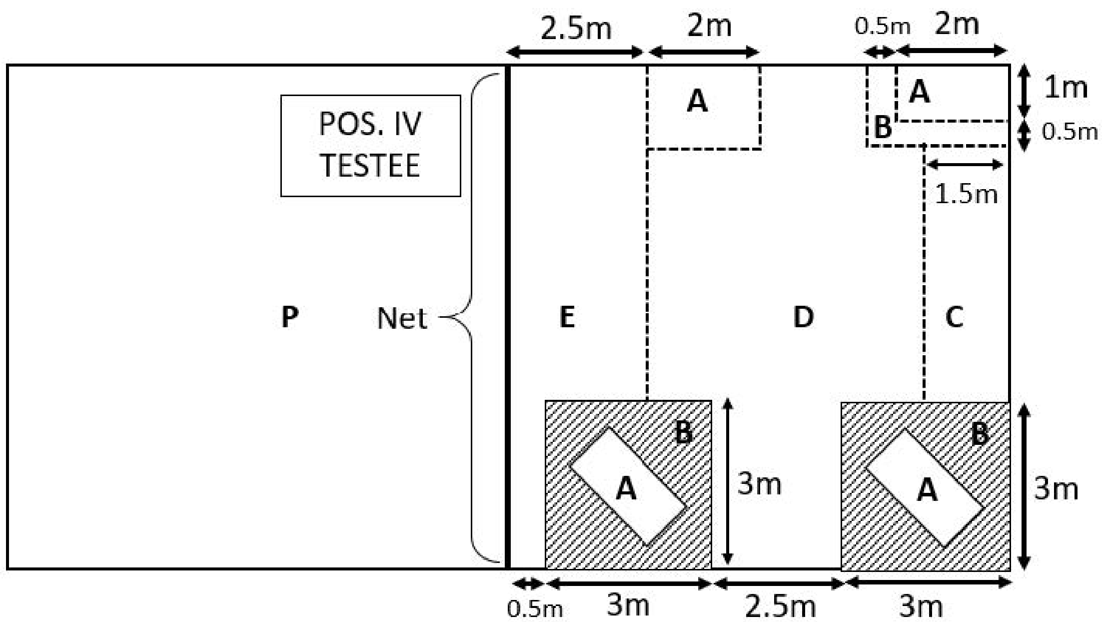

Figure 1. Upper view of scoring area of spikes [14]

Table 4. Comparison of measurement component between men and women

Components	Flight time	Force	Jump Height	Power	Velocity	Coordination	Spike Ability
Flight time	1	0.000**	0.000**	0.000**	0.000**	0.246	0.917
Force			0.000**	0.000**	0.000**	0.033*	0.502
Jump height				0.000**	0.000**	0.249	0.913
Power					0.000**	0.044*	0.576
Velocity						0.246	0.917
Coordination							0.003**
Spike Ability							1

* significant relationship (p-value < 0.05)ж ** significant relationship (p-value < 0.01)

Discussion

The topic of spikes is very interesting to learn about, and various innovations are made in terms of how to train and practice the skill. The discussion in this study is very related when viewed from the technical training program, because it refers to the primary reference in terms of the volleyball training program, i.e. the approach's footwork [15]. This study examines the components of the spike movement, demonstrating the ability of young male athletes to outperform young female athletes. In line with previous research, both male and female athletes have the same ability during the spike approach stage because they only rely on footsteps before jumping take-off. Female athletes' vertical jump ability is not significantly different [16], with an average of 3-4 feet to the jump [5]. However, what distinguishes males from females is the jump results, where the experience of the competition level is higher, thus distinguishing the ability and higher jump results [16]. Male volleyball players initiate different lower limb mechanisms than men when landing. It has been discovered that male and female college volleyball players have different landing strategies after spiking because it provides a very detailed perspective on the distribution of load on the lower extremity joints, which may influence the increased incidence of anterior cruciate ligament injury in women [17]. In one match, male athletes landed on the left (31.5 percent) or right (8.5 percent) foot more than female athletes (23.7 percent and 1.6 percent). The study looked at spike landings that showed unilateral landings (mostly left foot first for right-handed players) in both men and women, but men more frequently [18].

Every volleyball player wants to spike, but these days, being an all-rounder is the norm. When learning to spike, a player must understand the connection between all skills, movement patterns, and situations. A single examination of a complex skill can be misleading. Coaches must understand that open skills necessitate less control and parameters when teaching volleyball. Closed skills, on the other hand, necessitate a series of work tasks in order to progress toward the outcomes of the given practice material. In the case of spiking, coaches frequently design an exercise with too much information for the nervous system, making it too difficult for newcomers. When beginners see an image of a spike movement, they frequently remember it. However, in order to learn proper movement patterns, they needed to consider the entire skill. When teaching complex skills, it is strongly advised that trainers use video clips rather than still images. This step is a powerful tool for teaching beginners and intermediate level players technique. As players advance in skill, the use of e-tutorials (video clips) and videos becomes more appropriate. Because of advancements in video technology, coaches can now use e-tutorials to provide better models for athletes who want to learn [19].

In volleyball, a spike or attack is a strategy used to send the ball over the net to the opponent in such a way that the ball cannot be returned [20]. Spike is traditionally performed by jumping with both feet. In attack, a spiker usually takes a series of steps towards the ball. The volleyball approach refers to these steps. The goal of the volleyball approach is to get into the best attacking position. So far, jumping exercises performed in conjunction with attacks (countermovement) have proven to be more effective than jumping exercises performed alone [21]. When teaching a player how to approach and hit a volleyball, the two steps before the spike are a good way to start. After mastering the 2-step training method, the athlete can progress to the 3-step or 4-step volleyball approach [5].

According to a previous study, men have a better ability to jump when swinging their arms than female athletes [16], and the conclusion of this previous study is consistent with the findings of this study, that there is indeed a significant effect, particularly on the jumping performance variable, and the five indicators in this study were all significantly related and demonstrated male athletes' dominance over female athletes. Spike technique can be studied in greater depth for various spike movements (bow-and-arrow high and low, snap, and circular). The previous study attempted to investigate the analysis of the technique of turning the arm when spiked in beach volleyball, which has the same technical characteristics as indoor volleyball. This study included 96 elite beach volleyball athletes who used video recordings from the beach volleyball world championships. According to the findings, the two most common techniques were a low bow and arrow low (51.6 %) and a high bow and arrow high (51.6 %) (37.4 %). However, 11% of players used other strategies (circle: 6.6 %; snap: 4.4 %). Although the observed technique did not appear to affect performance, there was no significant difference in the performance of each player who mostly used variations of the arm swing technique [22]. Most importantly, when jumping, the approach or preparation step becomes the focal point, followed by hitting the ball. One female athlete study described important aspects of jump height as; i) optimized approach and energy conversion, ii) wider arm swings allowed for strong strike motion and, as a result, increased range of motion in the lower limbs, and iii) large angular velocity at the ankle and knee, particularly on the dominant side [8]. The support role of a specific joint may be affected by variations in attack technique.

Jumping is one of the issues that arises during the spike movement. The center of gravity of the body increases in spike with increasing jump distance compared to normal spiking, causing some postural changes in initial contact and ultimately increasing the ground reaction force values, peak ground reaction and average load rate. On initial contact, raised torso with elongated hips and slight knee flexion, followed by extensive joint space at the knees and ankles before moving to the heels. This is a critical component of a safer landing method [3, 23].

Spike technique is also linked to aspects of nutrition and injury risk. There are several types of fluid intake that, if consumed regularly and in the recommended amount, can provide additional energy that is positively correlated with increased physical performance leading to increased accuracy during actual volleyball matches [24], such as taking creatine supplements for four weeks and drinking caffeine-containing energy drinks [24]. It is also difficult to understand nutritional intake, what benefits can be provided when our food and beverage intake is balanced, and up-to-date knowledge of the development of nutritional science [25, 26]. Spike is performed by moving the arm with a wide arm span (the angle formed by the arm) to direct the ball to the opposing side of the field [11, 27]. Spike movement injuries are common and have the greatest impact on the shoulder [11]. A group of fourteen female college volleyball players completed five successful trials of four different skill types: two-directional spikes, off-speed rolls, and float serve. Volleyball players with symptoms of overuse of shoulder work will be able to reduce repetition performance during training if it is related to shoulder work function during spike work. Similarly, limiting the number of jumps while serving reduces the risk of impaired shoulder function caused by excessive repetition of the movement [9].

Based on just one technique of spike, it is possible to conclude that there are numerous supporting and inhibiting factors. Supporting factors include learning spike exercise material [4], using technology to record spike movements [19], and increasing nutritional intake [24, 28]. On the other hand, motion errors such as when the spike approaches [5], the importance of jumping ability [29], the angle made from the tool analysis during the spike motion [8, 9, 27] will affect whether or not the ball enters the opponent's the landing phase's importance [3, 30] and can even result in injury. The majority of which occur in the shoulder [11, 31, 32] demonstrates how the complexity of one move that significantly contributes to the outcome of a match is the spike technique [2]. Overall, it can be concluded, in accordance with previous research, that the jumping performance component is required by volleyball athletes, particularly at the beginning of talent identification. However, for young athletes, motor coordination is an important factor in determining spike ability that is considered worthy of entering the elite level of volleyball [33]. In light of the findings of this and previous studies, it is worth emphasizing that the maturity of mastery of jumping performance and coordination of motion during spikes is a slick combination that has the potential to be a mainstay weapon for lethal attacks on the opponent's points.

Conclusions

Coaches can use the information in this study as a guideline to develop training program to improve their athletes effectiveness in spiking. It is hope for the future study to be conducted on many more factors that can contribute to enhanced performance in volleyball, as a way to improve the quality of the game specifically among elite and beginner athletes for both men and women.

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Conflict of interest

Authors declare no conflict of interest exist in this study.

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ORIGINAL ARTICLE

The different influence of speed, agility and aerobic capacity toward soccer skills of youth player

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The significant influence of speed, agility and aerobic fitness on youth soccer performance is described by current football literature. The sensitive phases of age development of students have been stated to have a different influence compared to professional players. The purpose of this study was to determine the contribution of speed, agility and aerobic fitness on soccer skills to the Student Activity Units (UKM) of Football.

Material and Methods The method used in the correlation research study is a descriptive-quantitative with a cross-sectional approach. The population study was all 35 members of UKM football players and the sample was selected through purposive methods sampling. Furthermore, the instruments to be applied are (1) speed with 30 meters sprint test; (2) agility through a 5-meters shuttle run; (3) aerobic endurance by using the 20m Beep-test protocol; (4) soccer skill using David Lee's test. The SPSS 28 program was used for the statistical operations in the analytical data technique, followed by prerequisite analysis tests, namely the normality test and homogeneity test, as well as a hypothesis test to confirm the hypothesis.

Results The result shows that there is a correlation in positive values between both the independent and dependent variables. Statistical analysis confirms that there is a correlation and positive impact of speed, agility and aerobic capacity of football skills. Significant differences in correlations were found in the speed, agility and aerobic capacity of the participants ($p < 0.05$).

Conclusions Physical activity based on the anaerobic system has a positive effect on individual skills. In contrast, aerobic capacity plays a role more in the complex skills of football games in real situations.

Keywords: football skills, speed, agility, aerobic fitness

Introduction

Sports achievement can be achieved optimally if fulfills several supporting component requirements such as athletes talent, coaches, training programs that are managed with well-structured training management [1]. Other influenced technical factors such as training infrastructure and the welfare needs of coaches and athletes must also be considered by sports management. The current study also strengthens the psychological condition [2], the condition of the athlete's physiology, regeneration, body constitution [3], and the ability in skill, tactic, and strategy [4] as defining components are also needed to consider. An athlete's performance on the soccer field is commonly influenced by physical, technical, tactical, and psychological factors [5]. However, current strength and conditioning journals reported that bio-motoric ability plays a more significant role in support to perform as individuals and in teams [6, 7].

Bio-motor ability is an ability coming from the acclamation of exercise results, an exercise arranged based on the program made by coaches and a sports club [8]. Every athletes have a different characteristic level of bio-motor ability, therefore, a trainer should arrange an appropriate exercise program thoroughly to reach the exercise program itself [9]. It is required a program designed with individualism responses since everyone has an own level of bio-motor ability and different impact to the sport ability [8, 9, 10].

Different types of sports games have a dominant bio-motor difference applied including football [11]. Football is the most popular game sport by the community, played by 2 teams with a duration of 2x45 minutes and 2x15 minutes of extra time, carried out with high intensity with an intermittent stop and go nature so that it requires speed, skill, and endurance to play for 90 minutes [12, 13].

The recently applied journal has stated that the bio-motor abilities in soccer were dominated by speed, agility and aerobic capacity [14]. Football players are required to have good physical fitness to move from attacking to defending positions, shooting, dribbling, passing, heading and running

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around the field with a total distance of 10-12 km in each match [15]. The speed ability is required since an athlete needs to be active moving for dribbling, passing, attacking, and running around the field in a short time speed [16]. In the interrelation principles, speed in movement is also required to be able to produce power for kicking, jumping, and heading in combination with other bio-motoric components [14, 16, 17]. Another statement shows that agility has close interrelation between speed, coordination and flexibility [18]. Football, which is played on a large field, requires complex movement. In a sport where the direction of the coming and going ball is irregular, the movement ability in controlling, running to get a ball, jumping, making a sudden stop, or avoiding the opponent is required [19].

Agility is known as a body's movement ability to accelerate position into a one-way direction [20], accelerate a movement into opposite various positions at high velocity [21], and change a movement into multi-direction promptly in the good body mechanical position [22]. It shows that a football player needs the elements of agility as well as it can give some benefits for teams to make them able to perform an optimal pattern of attack and defense. Seems agility is an essential bio-motor aspect in football since the movements of football are performed in a fast way and in a short time execution [23], therefore agility is required to keep and maintain the ball possession from an opponent [24].

Aerobic endurance is a dominant aspect needed in every sport that requires a long time both in a match and competition including football [25]. Aerobic capacity is most crucial for sports games that need require high physical activities to be able to perform at a good level in long time duration and recover faster without any issues in physical fatigue [26]. The importance of aerobics capacity in soccer is also confirmed in a study that discusses the method to maintain good aerobic capacities in soccer and to provide proper recovery management to deal with the regeneration issues in soccer recently [3].

Football is a very popular sport among various levels of people starting from kids, and teenagers, to adult communities [27]. It was a common sports game played in every urban and rural area since it is friendly to play, has an understandable rule, and could be played in every ordinary facility for recreational purposes, or in good infrastructure for professional aims [28]. The pattern of coaching Indonesian football starts from the scope of youth clubs through *PPLP-D* or clubs handled by professional management [29]. This coaching is carried out on an ongoing basis with the aim of monitoring reliable young footballers in Indonesia who are able to carve football achievements in the international arena. However, the success ratio of senior athletes who have reliable football achievements compared to the population of Indonesia is still far below the standard. Indonesia has a very minimal number of elite athletes, despite having a large number of clubs with a huge population of more than 267 million. Sports management studies explain that in order to achieve maximum performance, good cooperation between coaches and management needs to be implemented in the planning and preparation of short, medium and long term training instruments [30]. The average PPLPD athlete already has a chronological age phase and an optimal training age so that they can be given training that is oriented towards increasing the volume and intensity of exercise progressively to see the adaptability and response to training of each athlete [31].

However, the lack of monitoring of the exercise schedule, rest time, becomes an obstacle to determine the progress of the exercise, so that the results of the exercise have not been well informed. As a result, the determination of the expected peak performance at the time of the competition has not been achieved, due to the lack of regular reports regarding the effect of given training on improving the performance of each training cycles [32]. Several general parameter tests have been carried out but have not provided a clear description of the relationship between parameter tests and soccer performance. In this case, measurements related to aspects of the dominant bio-motor components in soccer including speed, agility, and endurance on soccer performance need to be carried out [33]. Although several studies have shown that biomotor speed, agility and endurance can affect the level of soccer performance at the elite level, other strength and conditioning studies explain that in adolescence the elements of basic skills and techniques are prioritized. In addition, it is very important to know the choice of exercise priority between physical or technique that must be prioritized for PPLPD athletes to be able to provide an overview to the coach about how the relationship between speed, agility, and aerobic endurance affects the development of soccer skills. Thus, the purpose of this study is to determine the biomotor profile of speed, agility, endurance and soccer skills, it will also measure the relationship between each of these variables to the soccer skills of each athlete to be used as material for evaluating training programs, either individually or team

Materials and Methods

Participants

This research was conducted at Yogyakarta State University (UNY) which is located at Jalan Colombo No. 1 Yogyakarta. The study was carried out on August 27^{th} to October 23^{rd}, 2021. The population taken in this study were all students who were members of the University Soccer Club

(USC) at UNY, while the sampling technique used purposive sampling which was carried out by taking subjects based on age aspect screening, weight, gender, physical condition, health profile and soccer skills. The use of purposive sampling is used by considering reliable sampling based on information obtained quantitatively, to strengthen the required data. This experimental study used a correlation method with the descriptive-quantitative with cross-sectional approach [34] involving 35 male athletes (aged 18.33±1.31, BMI 21.34±1.49, RHR 71.4±6.7bpm, Lactate 2.34±0.52mmol/l), selected through inclusion and exclusion criteria and were prepared for national student competition [35]. The study begins with signing an informed consent in accordance with university policy and approved by the University Research Ethics (Approval Number KE/FK/1012/EC/2021).

Research Design

The variable of this research consists of two independent variables and one dependent variable. The independent variables are the speed (X_1), agility (X_2), and aerobic capacity (X_3). The dependent variable in this research is the result of football skill testing. The design of the study is to examine the relationship strength among two or more events or traits or to describe the relation between the independent variable such as speed (X_1), agility (X_2), and aerobic capacity (X_3) to and the dependent variable of soccer skills (Y). The test begins with examination of samples by doctors and physical trainers to check health status, physiological including the absence of cardiovascular complaints, followed by measurement of height and weight. The speed ability was carried out using a 30m straight sprint test on a running track with a standing start [36] using a sensor-based digital measuring instrument, and the agility tests were carried out using the 10m shuttle test protocol [37]. The aerobic endurance test was carried out using the 20m beep-test [38], and the soccer skill test was carried out using the David Lee Soccer skills protocol with a validity of 0.73 and a reliability of 0.8 [39].

Statistical Analysis.

The data analysis technique used prerequisite test, normality test, linearity test, correlation test, and homogeneity test, and hypothesis testing was used with SPSS 28.

Results

The initial data collecting was started with several aspects including Ages, Body mass index (BMI), Resting Heart Rate (RHR) and Basal Lactate Level to confirm whether samples are in normal status. The description of mentioned data will be displayed as follows.

The result (table 1) shows that mostly participants have a productive age group (18.33±1.31 yr.), having a normal level of Health Status as shown in BMI (21.34±1.49kg/m^2), without having issues with fatigue condition as described in Resting Heart Rate (71.4±6.7 bpm) and Lactate Profile (2.34±0.52 mmol/l). This explanation can be interpreted that the sample is assumed to have relatively the same condition in terms of age, health and fitness so that it is believed not to have a high bias value. Another simultaneous quantitative measurement to show the characteristics of speed, agility, aerobic and soccer skills experienced conducted after pre-requisite check and describes as below (table 2).

Table 1. The characteristic of Ages, BMI, Pulse rate and Lactate

Variables	N	Mean+Std. Deviation	Std. Error
Ages (years)	35	18.33±1.31	19.5
BMI (kg/m^2)	35	21.34±1.49	59.4
Resting Heart Rate (pulse/minute)	35	71.4±6.7	21.2
Lactate (mmol/l)	35	2.34±0.52	33.8

Table 2. Descriptive Statistics

Variables (n=35)	N	Percentage (%)	Mean+Std. Error
High Speed (<3.8)	6	17.1	
Moderate Speed (4.1–5.4)	22	62.9	4.75 ± 1.32
Low Speed (>5.4)	7	20.0	
High Agility (>5.1)	19	54.3	
Moderate Agility (6.5–7.5)	13	37.1	6.12 ± 1.96
Low Agility (> 7.5)	3	8.6	
High Aerobic (>11)	7	20.0	
Moderate Aerobic (7 – 9)	24	68.6	8.27 ± 2.76
Low Aerobic (<5)	4	11.4	

From the conclusion above (table 2), it can be seen that in the speed category, more than half of the samples showed in moderate level, which was shown at 62% with an average running speed of 4.75 seconds in 30 meters, another 17% had a high level of speed with an average time below 3.8 seconds, and the remaining 20% are only able to run with a time above 5.4 seconds so that it is included in the low category. For the speed ability, it can be concluded that the average sample has a moderate level of speed, indicated by 4.75 ± 1.32. at the agility aspect, the data above shows that the majority of the sample has high agility as much as 54.3%, while 37.1% of the sample has sufficient agility and 8.6% is found to have poor agility. It can be concluded that the average sample has good agility with an average value of 6.12 ± 1.96. On the aspect of aerobic endurance, only 20% of the samples showed high aerobic endurance abilities, while the majority of samples were only at a moderate level with 68.6% and the remaining 11.4% were shown to have low aerobic endurance abilities. Overall, it can be concluded that the sample has moderate aerobic endurance with an average score of 8.27 ± 2.76.

The further step taken after descriptive is conducting the analysis prerequisite testing of which the data is examined through 3 stages, namely normality, homogeneity, and hypothesis testing. The following is the explanation of the testing in detail.

The Normality Test

The normality test is used to determine whether the dependent variable, independent variable, or both variables are normally distributed or close to normal [40]. According to Samantha [41], the implementation of the normality test can use the Kolmogorov-Smirnov test, with applicable criteria where a significant result > 0.05 means that the residuals are normally distributed. The following are the results of the normality test on the research variables carried out.

Based on these results (table 3), it can be seen that the significance value shows the number 0.998 which can be concluded that the variables in this study are normally distributed both as independent variables and dependent variables.

The Homogeneity Test

The homogeneity test is a test to find out whether the distribution of two or more variances has similarities. The homogeneity test that will be used in this study is the homogeneity test of variance and the Bartlett test. A homogeneity test was conducted to find out whether the data on variable X and variable Y was homogeneous. The homogeneity test can be stated that the research population has homogeneity or is similar if the significance value obtained is <0.05. The results of the homogeneity test can be seen in the several table (table 4, 5, 6) below.

The results of the homogeneity test can be seen (table 4) that the significance value of the speed variable is 0.033, while the agility variable indicates 0.002 (table 5) and the homogeneity value of aerobic endurance variable shows a significance value of 0.002 at table 6. Based on these results, it can be concluded that all research variables have a homogeneity as evidenced by a significance value below $p<0.05$

The Linearity Test

The linearity test can be used to determine

Table 3. Normality Test's Result

Variables	Speed test	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Football skill	42.00	.260	2	.			
	399.00	.260	2	.			
	405.00	.260	2	.			
	419.00	.260	2	.			
	428.00	.260	2	.			
	446.00	.217	3	.	.988	3	.791
	462.00	.260	2	.			
	467.00	.260	2	.			

Table 4. The Speed towards the Football Skills

Variables		Levene Statistic	df1	df2	Sig.
Football skills	Based on Mean	3.825	7	9	.033
	Based on Median	2.563	7	9	.095
	Based on Median and with adjusted df	2.563	7	2.000	.309
	Based on trimmed mean	3.743	7	9	.035

Table 5. The Agility towards the Football Skills

Variables		Levene Statistic	df1	df2	Sig.
Football skills	Based on Mean	8.128	7	10	.002
	Based on Median	1.591	7	10	.244
	Based on Median and with adjusted df	1.591	7	3.187	.372
	Based on trimmed mean	7.135	7	10	.003

Table 6. The Endurance towards the Football Skills

Variables		Levene Statistic	df1	df2	Sig.
Football skills	Based on Mean	8.128	7	10	.002
	Based on Median	1.591	7	10	.244
	Based on Median and with adjusted df	1.591	7	3.187	.372
	Based on trimmed mean	7.135	7	10	.003

Table 7. The Linearity Test's Result

ANOVA[a]					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	2947561.512	3	982520.504	.427	.735[b]
Residual	71320260.374	31	2300653.560		
Total	74267821.886	34			

a = Dependent Variable: football skill; b = Predictors: (Constant), aerobic endurance test, agility test, speed test.

whether the independent variable has a significant linear relationship with the dependent variable [41]. The linearity criteria can be conducted through the test of linearity. Linearity criteria can be done through linearity test. The criterion that applies is that only if the significance value is > 0.05, it means that there is a linear relationship between the independent variable and the dependent variable. The following are the results of the linearity test.

Based on the linearity value above (Table 7), it can be seen that the significant value shown is 0.427. Thus, it can be concluded that both the independent variable and the dependent variable in this study have a significant relationship where the three independent variables affect the dependent variable.

The Correlation Test

The Correlation test is a test used to determine the level of closeness of the relationship between the three independent variables with one dependent variable with a value of 0 (zero) to 1 (one) [42] . If the significance value (r) is close to the number 1 (one), it can be stated that the variable has a close relationship and vice versa. The results of the correlation test can be seen in the table below.

Based on the results above (table 8), it can be seen that the correlation value between speed and soccer skills shows a significant number of -0.143, which implies that the speed variable has a small degree of relationship in the opposite direction. This means that every increase in the ability of soccer skills will affect a decrease in speed with small relationship strength. The correlation value between agility and soccer skills shows a significant number of 0.034, which means that the speed variable has a small relationship with a positive direction. This means that every increase in agility ability will also affect the improvement of soccer skills with small relationship strength. Meanwhile, the correlation value between aerobic endurance and soccer skills shows a significant value of 0.130, which means that speed has a small relationship with a positive direction. This means that every increase in aerobic endurance will have an effect on improving soccer skills on a small scale of relationship strength. It can be concluded that speed, agility and aerobic endurance are shown to have a low correlation with soccer skills.

Discussion

The quality of speed in soccer is influenced by the quality of exercise, rest, healthy lifestyle, and environmental and genetic factors that affect the type of muscle fibers possessed [43]. Several studies explain that fast-twitch muscle types are able to provide greater and stronger force quickly, however, have a shorter duration of contraction, and are exhausted quickly because they have less blood supply, so they are classified as anaerobic contractions [44]. On the other hand, slow-twitch muscle types have more mitochondria and myoglobin and are aerobic than fast-twitch fibers, hence more resistant to fatigue, on the smaller sustained contractions [45]. In soccer, the basic need for speed is needed in

Table 8. The Correlation Test's Result

Variables	The Correlation Test	Speed	Agility	Aerobic Endurance	Football Skill
Speed test	Pearson Correlation	1	-.139	.062	-.143
	Sig. (2-tailed)		.426	.722	.413
	N	35	35	35	35
Agility test	Pearson Correlation	-.139	1	.051	.034
	Sig. (2-tailed)	.426		.769	.848
	N	35	35	35	35
Aerobic	Pearson Correlation	.062	.051	1	.130
	Sig. (2-tailed)	.722	.769		.458
	N	35	35	35	35
Soccer skill	Pearson Correlation	-.143	.034	.130	1
	Sig. (2-tailed)	.413	.848	.458	
	N	35	35	35	35

almost all aspects of basic soccer movements such as running for the ball, dribbling, receiving the ball, kicking the ball, and other explosive movements [46]. Speed is an adaptation of strength training, so strength is an important aspect that supports speed in performing some basic soccer techniques [47]. This is explained by studies that explain the determination of anaerobic speed in addition to being determined by the type of muscle fiber, nerve-muscle coordination, and biomechanical aspects, the contribution of muscle contraction strength has a significant influence on the speed produced [48]. Another study also added that regular muscle strength training with the method of concentric and eccentric contraction types had the effect of increasing optimal sprint speed [49]. It can be concluded that the element of strength is a crucial aspect in the development of speed aspect, so the element of weight training related to increasing speed must be given in an orderly, planned, and measurable manner to soccer players.

Another physical demand in soccer is the ability to move quickly, and change movements in various directions accompanied by good ball control coordination, which is also the main demand to be able to play ball optimally [50]. This statement is strengthened by another study of games analysis, which explains that having good speed skills will have a high correlation with the demands of agility in playing soccer [51]. Agility is a combination of some physical elements such as the element of strength, speed, and flexibility. The element of strength is required in the early process of body movement when supporting or rejecting legs. The element of speed is required to move fast from one point to another. Meanwhile, the element of flexibility is needed to bend or move body parts leading to the next movement [52]. Motor agility must be possessed to be able to move from one place to another in a very short time. This statement was confirming that agility is related to speed and flexibility, which is also confirmed another study also confirmed that the factors that affect agility are reaction speed, motor coordination, balance control, and joint flexibility [53]. In this case, it can be concluded that strength can be transformed into an element of speed, where speed will produce agility if it is equipped with motor coordination and flexibility in basic sports movements. On the other hand, the quality of speed-running is explained to be influenced by leg length and stride length, which is the product of the multiplication of stride length and frequency per the second step [54]. In this case, students who have heredity aspects related to long leg length are assumed to have the main modality of factors that can produce optimal stride length. However, the results of the biomechanics study explain that the relationship of leg length is not always positively correlated with running speed. It is associated that the resulting stride length, proved to be significantly affected by the propulsion force of the foot in the contact phase with the ground, which was carried out with a time of less than 200ms/step [55]. The conclusion obtained is that the anthropometric profile of students related to leg length contributes positively to speed-running, as long as accompanied by aspects of strength to produce optimal foot propulsion in a short time. The correlation of agility to basic skills in football in the technique of passing, dribbling, and shooting in a team, is explained to have a significant influence so the inter-relationship of agility training with skills packaged through the defense and attack patterns needs to be given comprehensively [56]. The results of the study that explain the correlation value of agility to soccer skills on a small scale in this study are believed to be because it only involves the agility aspect. So, in its development, it is necessary to do calculations involving more variables to see the correlation more significantly. In addition, another conclusion obtained is that to improve soccer skills, agility training needs to be given through a comprehensive form of motor coordination training involving other bio-motor aspects, which are packaged with specific game methods.

However, previous study provides another controversial opinion that explains since winger attack, full-backs and playmakers position have to repeatedly run across the field for a long time, and perform rapid sprints to control the ball, which requires sufficient endurance ability, hence the dominance of the slow-twitch fiber type has also been shown to have a significant effect [43, 44, 45, 57]. This is explained in previous studies that excellent physical endurance will have a positive effect on increasing blood circulation and the ability of the heart to work, increasing strength, flexibility, endurance, coordination, balance, speed, and body agility [58]. In addition, it will also have an effect on increasing the ability to move efficiently and increasing the ability of the body's organs after exercise as well as increasing the body's response ability [7].

Sports physiology studies explain that anaerobic endurance is needed in soccer to meet energy needs through converting glycogen into an energy source without the help of oxygen which is correlated with maximum contraction speed using anaerobic energy sources [23].

However, aerobic endurance in soccer is also needed to be able to supply oxygen optimally in its need to break down fatigue and get a good speed of fatigue regeneration with the availability of an optimal oxygen supply [59]. This study examines the correlation between aerobic endurance and soccer skill, which shows a correlation on a small scale. It is believed that because soccer skills are strongly influenced by bio-motor aspects and high technical mastery, the involvement of aerobic endurance elements alone is believed to be insufficient to describe the level of correlation and its influence on soccer skills [17]. Therefore, the involvement of various bio-motor aspects, mastery of basic techniques is expected to be involved in further studies to be able to comprehensively describe the level of correlation with soccer skills.

Conclusions

Based on the results of the data analysis and discussion above, it can be concluded that there is a contribution between speed, agility, and aerobic endurance to the skills of university soccer players at Yogyakarta State University. Through this research, it is hoped that it can become useful basic data for coaches at Yogyakarta State University to evaluate the ongoing coaching program.

Conflict of interest

There is no conflict interest declared by the authors.

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06

ORIGINAL ARTICLE

The effectiveness of folk physical activity and food education programme on body mass, nutrition knowledge and consumption behaviour among overweight primary school children in Southern Thailand

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Overweight status among primary school children is recognized a major public health problem in Thailand. As the rates of overweight is higher than the key performance indicator targeted by the government, it is important for necessary measures and actions to be taken to solve the problem. This study aimed to determine the effectiveness of folk physical activity and food education program on body mass, nutrition knowledge score and consumption behaviour among overweight primary school children in Southern Thailand.

Material and Methods Thirty-eight (N=38) primary school children of grade 4-6 were recruited and divided into experimental group (13 boys and 6 girls) and control group (12 boys and 7 girls). The intervention was conducted in six weeks. Data were analyzed using descriptive statistics and inferential statistics.

Results Results showed the post-food consumption knowledge and behaviour between experimental and control groups were significantly difference ($p<0.001$; $p<0.05$), respectively. Post-body mass of experimental group decreased after participation ($p<0.01$) and it is in contrast to control group which significantly increased ($p<0.01$).

Conclusions Results demonstrated that the combination of providing appropriate physical activity programme and food consumption education can result in reducing body mass among overweight primary school children. Besides, children can also learn about the food consumption and apply it as behaviour from younger age. Such programme should be promoted among all students continually and should be added and frequently conducted in the school health programme, so that student can do it as their daily routine towards realizing the national plan of having healthy generations in the future.

Keywords: physical activity, food consumption education, overweight student, body mass index, knowledge and behaviour.

Introduction

Overweight status among primary school children is recognized a major public health problem in Thailand. It is reported that there are high percentage of overweight among primary school children (12.57 per cent) that are above than key performance indicator targeted by the Ministry of Public Health, Thailand (10 per cent). Overweight problem among this group shows 1.7 fold increased in 12 years [1]. Student aged 6-14, in particular has increased from 11.14, 11.19 to 12.89 per cent between 2017 and 2019 (Health Data Center, 2015). Bangkok shows the highest percentage of overweight school student (23.94 per cent), Surat Thani is the second most (15.41 per cent) area whereas Nakonnayok reported the third range of the country (15.07 per cent). Nachon Sri Thamarat province, located in rural area, reach a position high, numbering 21st in Thailand [2]. It can be seen that the prevalence rate of overweight child is increasing even in the rural far areas.

There are various causes of getting overweight health among primary school children. Physical activity and food consumption are found to be common factors contributing to obesity [3]. The imbalance between intake and metabolic energy leads to fat gained. Physical inactivity and imbalance food consumption behaviour are well recognised as main causes of overweight [4, 5]. From the literature review about consumption behaviour among primary school children, they prefer high energetic food but there contains low nutrient for good health such as fast food, snake, hamburger and cake [6]. The world today supports the individuals to rely on technology and digital used to provide convenient daily living.

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Children spend most of their leisure time sitting in front of television and play games around 2-3 hours a day rather than performing physical activity. Learning environment does not support student to have enough physical movement. Daily study schedule is designed for student to sit on their desk and this reduces energy expenditure. In addition, most student spend less than 30 minutes a day and less than 3 times a week for this activity. Although they can do physical activity and exercise during physical education class, it runs for only 50 minutes a week. So it is not sufficient for spending energy and keep them in balance weight in their age [7].

These overweight children also have higher risk of health problem including chronic illness and easy susceptible to other health problems when they turn to older age; hypertension, diabetes, cardiovascular disease, for instance. Apart from this, overweight health condition can affect academic performance and related activity that fulfill the proper growth and development of school aged children [1, 3]. Among children who are 5-18 years old would have higher risk to stroke than those who have normal weight. The trend of hypertension also increases 2-4.5 folds while high cholesterol approach to 3-7 folds [8]. Being overweight child is somehow a stigma issue because they could be bullied by friends and people around them. This could affect their mental health and bring negative outcome in the long term. Some might also lose confident to participate in class and activity. Some could become depress and even lead to suicide [3, 8]. Thus, it can be said that being overweight not only create burden to individual children, it increases health care cost, reduce quality of live and can have short life expectancy [8].

The data from weight analysis among grade 4-6 children from 2017-2019 in local school of Nachon Sri Thamarat province; Watsamakeenukul school reported by school health division showed that percentage of overweight among this group increases progressively from 4.89 per cent in 2017 to 5.29 in 2018 and to 8.89 in 2019. They have insufficient knowledge and understanding of the benefit to have proper physical activity and consume healthy food. They do have big meals 3 times per day. After school, they become very hungry and this causes chance of gaining more calories but children have low energy expenditure [3].

From literature, the combination of physical activity and food education programme can balance body weight and promote the individual a good health [8, 9]. This particular intervention still not exists in the rural school. Thus, this study was aimed to determine the effectiveness of such program to body weight among overweight primary school children of grade 4-6. In this study, we design physical activity based on local wisdom as it would suit context and lifestyle of study participant better, hoping that they will enjoy and include as part of their daily life. The finding can enhance relevant sector to support children an appropriate physical activity and consume healthy food to maintain balance weight. They can grow up to be healthy adult and be a good human resource for the nations development in the future.

Material and Methods

Participants

This quasi-experimental study involved primary school children of grade 4-6 by using purposive sampling. Thirty eight (N=38) participants based on inclusion and exclusion criteria were recruited. The inclusion criteria include: i) being student of grade 4-6; ii) having body weight higher than +2SD; iii) having no personal health problem and iv) obtaining permission from parent to participate in the study. The exclusion criteria were those that do not comply with the inclusion criteria and did not able to participate in all the programs conducted due to personal reason or having illness or injury during the experimental period. The participants were randomly recruited into control (N=19) and experimental groups (N=19). This study was approved by the institute ethical review board of Thaksin University, Thailand (No. 202-105)

Instrumentation and validation

The research instruments used in this study consisted of 2 parts: i) the questionnaire of general information, food cognitive assessment and food consumption behavior [2, 10] and ii) the guideline of how to eat healthy food combined with folk activity programme. The researchers assessed instrument of the second part by using content validity and reliability. The index of item objective congruence (IOC = 0.88) was evaluated by 3 experts from health and sports sciences department to check the validity of the content, coverage, clarity of language and suitability. After that, the researchers took into consideration on how to improve the language, content of the guideline and programme according to recommendations. The reliability was ensured by Cronbach's alpha coefficient (a =0.69) which was tested on 30 children who have characteristics as same as the sample group from other school.

This study followed Thailand national guideline of growth specific for children aged 5-18 years old [11]. According to this guideline, weight by height was used to identify obesity or thinness child. For overweight children, in particular, it is determined by +2 S.D.

Folk physical activity and food consumption behavior programmes

The programmes for this study combined of folk physical activity based on local lifestyles and cultural contexts and food consumption behaviour. The details were shown in Table 1.

Statistical analysis

The general characteristics and independent variables were analyzed by descriptive statistics (frequency, percentage, mean, and standard deviation). Whereas, inferential statistics were analyzed to compare the body weight between experimental group and control group by using independent t-test and to compare the food cognitive and food consumption behavior scores by using χ^2 at the significant level of 0.05 respectively.

Results

Table 2 showed the characteristics of participants. Table 3 showed the body weight by height among experimental and control groups. It can be seen that the number of obese was drop from 14 to 13 and pre-obese from 5 to 4 among experimental group. In contrast, the number of obese increase from 12 to 15 among control group.

Table 4 showed the knowledge of food consumption and food consumption behaviour pre- and post-intervention. No significant difference was found in the pre-test. In the post-test, experimental group was shown to improve in terms of these variables and also were shown to be significantly greater compared to control group.

Table 5 showed that the body mass of experimental group after participation (65.53±13.59 kg) was significantly decrease when compared to before (66.68±13.75 kg) (p<0.01). In contrast, the body mass of control group after (65.00±13.04 kg) was significantly increase when compare to before participation (63.78±12.88 kg). As, the body mass before participation between experimental group and control group was not difference. Same with

Table 1. Programmes for participants

Week	Study procedures: Experiment group	Study procedures: Control group	Duration per day
	Pretest- Body assessment		
1	Body weight assessment Evaluating knowledge of healthy food consumption	Body weight assessment Evaluating knowledge of healthy food consumption	50 mins
How to eat to prevent obesity			
2	Leaning about obesity and its cause through video Knowing how to prevent obesity Brainstorming and sharing their thought about the negative of obesity to their life and the research concluded issues Knowing about healthy meal and make own choice Knowing about folk physical activity and its typical		50 mins
2-7	**Folk physical activity practise**		
	Warming up (10 min) "Yhon ball" based on figure of eight model (4 min and 2 min break) " Pra kong blloon" (4 min and 2 min break) " Wing sam kha" (4 min and 2 min break) " Tee luk lore" (4 min and 2 min break) " Wing peaw" (4 min and 2 min break) Cool down (10min)		50 min
7	**Post test**		
	Body weight assessment Evaluating knowledge of healthy food consumption	Body weight assessment Evaluating knowledge of healthy food consumption	50 min

Table 2. Characteristics of participants

Characteristics		Experimental group (n=19)	Control group (n=19)
	Number (%)		Number (%)
Sex			
	Boy	13(68.4)	12(63.2)
	Girl	6(31.6)	7(36.8)
Age (Years)			
	10	3(15.8)	6(31.6)
	11	10(52.6)	6(31.6)
	12	6(31.6)	7(36.8)
Religion			
	Buddhist	19(100.0)	19(100.0)
GPA			
	3.60 - 4.00	5(26.4)	1(5.3)
	3.00 - 3.59	7(36.8)	8(42.1)
	2.60 - 2.99	7(36.8)	8(42.1)
	Less than 2.60	0(0.0)	2(10.5)
Weight (kg)			
	41.0-50.0	0(0.0)	2(10.5)
	51.0-60.0	8(42.1)	6(31.6)
	61.0-70.0	5(26.3)	8(42.1)
	71.0-80.0	4(21.1)	1(5.3)
	81.0-90.0	0(0.0)	1(5.3)
	91.0-100.0	1(5.3)	1(5.3)
	101.0-110.0	1(5.3)	0(0.0)
Height (cm)			
	131.0-140.0	1(5.3)	2(10.5)
	141.0-150.0	9(47.4)	6(31.6)
	151.0-160.0	6(31.6)	8(42.1)
	161.0-170.0	3(15.8)	3(15.8)

Table 3. Bodyweight by height among experimental and control groups

Weight by height	Experimental group	Control groups
	Number (%)	Number (%)
Before experiment		
Overweight	0 (0.0)	0 (0.0)
Pre-obese	5 (26.3)	7 (36.8)
Obese	14 (73.7)	12 (63.2)
After experiment		
Overweight	2 (10.5)	0 (0.0)
Pre-obese	4 (21.1)	4 (21.1)
Obese	13 (68.4)	15 (78.9)

Table 4. Knowledge of food consumption and food consumption behaviour in experimental and control groups.

Variable	Experimental group n=19		Control groups n=19		χ2	p
	Number	%	Number	%		
Before experiment						
Knowledge of food consumption						
Good	0	0	0	0		
Fair	11	57.9	11	57.9	0.00	1
Improved	8	42.1	8	42.1		
Food consumption behaviour						
Good	0	0	0	0		
Fair	12	63.2	16	84.2	1.03	0.60
Improved	7	36.8	3	15.8		
After experiment						
Knowledge of food consumption						
Good	12	63.2	0	0		
Fair	6	31.5	12	63.2	18.5	<0.001
Improved	1	5.3	7	36.8		
Food consumption behaviour						
Good	3	15.8	1	5.3		
Fair	16	84.2	15	78.9	10.57	0.005
Improved	0	0	3	15.8		

Table 5. The comparison of body mass between experimental group and control group before and after experiment

Body mass (kg)	Control group		Experimental group		t	p
	mean	SD	mean	SD		
Before	63.78	12.88	66.68	13.75	0.67	0.50
After	65.00	13.04	65.53	13.59	0.13	0.89
t	6.05		-6.60			
p	<0.01*		<0.01*			

body mass after participation between experimental group and control group was not difference.

Discussion

The purposes of this study were to compare body weight, knowledge of food consumption and food behaviour between experimental and control group, before and after participation following the programme on body weight among overweight primary school children of grade 4-6. In line with what was found in several previous studies [4, 7, 8, 9], findings of the current study showed the body weight of the experimental group after the experiment was reduced compared to before the experiment. In contrast to the body weight of the control group after the experiment was increased when compared to before the experiment.

Such folk activities are activities that children like and are challenging while participating in the activities. It effects on the weight loss, decrease fat mass and increase muscle and bone mass in this age group. It also motivated and challenge to them for participating the programme [4, 6, 7, 8].

Children physical activity should be organized into multiple stations by alternating muscle groups from station to station in which one round of exercise consists of a minimum exercise of 5-8 stations, an intermediate exercise of 9-11 stations, or a maximum of 12-15 stations. They may repeat several rounds depending on the amount of exercise considering the number of stations, repetition per station and the intensity of each exercise period that resulting in the highest efficiency in training [12, 13, 14].

In terms of knowledge about food consumption, it was found that the experimental group joined the activities that the researcher had organized with educate to participant by leaflets and dietary guidelines in school-aged children. The proportion of food that school-age children should consume and the amount of food that should be had and the type of food that should be eaten according to the color light food classification game according to traffic light color zones. To test knowledge and understanding of food choices, with power point as a media to educate for the sample group to understand the content better be able to act on food consumption properly and ability to recognize good response. Similarly, Chukaew [15] examined the effect of a nutrition self-management program on dietary behavior and weight among obese high school-aged children. The subject played a game of cards to practice grouping food. It was found that the students in the experimental group had more knowledge scores than before the experiment and different from the control group. As well as, Panmanee and Prabpai [16] studied the effect of a behavioral diet promotion program using planned behavior theory on weight loss behaviors of overweight school-aged children by organizing to educate about food consumption from the weight loss guide according to the proper food schedule, to brainstorm how fat affects life and how it affects the body, and to watch the obesity disaster video. It was found that after the experiment, the experimental group had an attitude score, referral group conformance, the efficacy intention in the weight loss behavior was higher than before the experiment and higher than the control group.

The results of this research support the concept of behavioral mapping theory that human behavior is guided by three beliefs: behavioral beliefs if individuals believe that behavior leads to positive retribution and a person would have a positive attitude towards that behaviour. But if it is believed to lead to a negative, there would be a bad attitude towards the behaviour. Normative beliefs are beliefs in another person that are important to one's self and tend to follow that person's behaviour. Control beliefs are perceptions of the ability to control behavior. It indicated that the educational activities that the researchers applied were consistent, giving the experimental group a greater understanding of food choices. As for consumption behavior, after the experiment, the experimental group had better food consumption behavior than the control group. It can adjust the food consumption behavior of the experimental group in a better way. Increased awareness of behavior modification, recognize the causes of the overweight, the effects of being overweight and the potential future risks or negative consequences of being overweight such as type 2 diabetes, high blood lipids, high blood pressure etc.

In our study, from our conversation with school teacher, the continuing increase of overweight child was possibly because children have low participation in physical activity and consume junk food. Not only that, from our observation after school hour, nearly all children bought junk food: soft drink, meat ball and french-fried selling in front of school before going home. This becomes their routine behaviour. Thus, as they had been involved in this study, with the knowledge that gat, we hope for adaptations to occur on their habit of eating behaviour. Besides, we also hope for the involvement of parents in educating and controlling children physical activity and dietary habit as previous study had demonstrated this step will play a role to attain the objective [3, 17] besides they also become the role model for the children [18]. The cooperation between teachers, parents and organizations are hope to be implemented in order to make the future generations more healthy and active [1, 6, 19, 20].

Conclusions

This study is the starting point for designing to reduce body weight of overweight school age children. To focus on their context, lifestyle and culture in order to facilitate the practical implementation for weight reduction are important to promote in school and their family. However, there are still suggestions for further study including:

1. The duration of the study should be increased to at least 12 weeks for a definite change in body weight and overall health outcomes. However, this study can carry out only 7 weeks because of the pandemic of COVID 19. The researchers have to stop the programmes as the school has to close and rely on online platform for all school activities.
2. It needs to develop a programme of children folk activities that are diverse and meet the needs of overweight school-aged children to have fun, more challenge but not to cause boredom to carry out activities regularly and have a sustainable impact on health.

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Conflict of interest

There is no conflict of interest

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ORIGINAL ARTICLE

Increasing the functional capabilities of Mixed Martial Arts athletes in the process of optimizing different regimes of power load

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim To study the influence of power load regimes different in energy supply and intensity on functional capabilities of Mixed Martial Arts (MMA) athletes.

Material and Methods We examined 75 men aged 19±0.7 who had been practicing MMA for 4±0.8 years. The athletes were divided into 3 groups, 25 participants in each group. The study participants used power load regimes of different intensity in conditions of anaerobic-glycolytic and anaerobic-alactate energy supply of muscle activity. The study lasted 12 weeks. To assess the functional capabilities of athletes in these conditions we used the method of maximum strength development (1 RM). Control of biochemical blood parameters (creatinine, lactate dehydrogenase, testosterone) allowed determining features of adaptive and compensatory body reactions in response to loads.

Results During the study the 3rd group athletes showed the most pronounced increase (by 40.1%; $p<0.05$) in strength capabilities development. These changes were observed in conditions of anaerobic-alactate mechanism of energy supply. The smallest dynamics in the studied indicators was fixed in group 1 athletes. They used low-intensity training loads in conditions of anaerobic-glycolytic mechanism of energy supply. The results of laboratory studies showed different changes in the studied biochemical parameters of blood. The basal creatinine level in group 3 athletes was 12 times higher than in group 1 athletes. Lactate dehydrogenase (LDH) activity in group 1 athletes increased by 10 times in response to physical load compared to group 3 results. The basal level of LDH activity increased in group 1 (by 14.6%) and 2 (by 6.7%) athletes. The basal testosterone level increased in athletes of group 3 (by 14.4%) and 2 (by 5.6%). The basal level of the studied hormone had no changes in group 1 representatives.

Conclusions Accelerated increase in functional capabilities of MMA athletes was observed during high-intensity power loads in conditions of anaerobic-alactate energy supply mechanism. Using this power load regime will strengthen the adaptive body reserves of athletes at the stage of specialized basic training. Determining characteristics in the studied biochemical indicators in response to stress stimuli will allow to optimize training load regimes. The changes in these indicators will also allow to improve strength training in MMA in the shortest possible time.

Keywords: Mixed Martial Arts, functional capabilities, load regimes, biochemical blood parameters, intensity, training.

Introduction

The complexity of the training system optimization in Mixed Martial Arts (MMA) lies in finding the most effective and at the same time adequate to the body adaptation reserved options for using different intensity, volume, direction of physical exertion. This is used on the background of a wide range of training exercises taking into account the peculiarities of technical skills and tactical tasks [1, 2, 3]. Solving the problem of increasing the functional capabilities of athletes, meeting the requirements of competitive activity (especially at the professional level in MMA), is one of the priority tasks for specialists: in physical education and sports [4, 5]; for scientists who study the processes of body adaptation to stress stimuli of various directions [6, 7]. The need for the simultaneous development of explosive power to ensure the effectiveness of attacking actions and power endurance in the process of countering the opponent on the ring complicates the mechanism of optimizing training loads in MMA [8]. Increasing the

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functional capabilities of athletes of the striking or wrestling style of fighting requires the activation of completely opposite energy supply mechanisms for muscle activity and different physical loads in terms of volume and intensity. This is which complicates the optimization of the main structural elements of the training system in MMA [9]. However, specialists in the problems of improving training activity in martial arts have recently paid close attention to the issue of studying the mechanisms of correction of training load indicators noting the individual functional capabilities of the body [3, 10, 11]. The issue of determining informative markers for evaluating adaptive and compensatory body reactions (in conditions of training and competitive activity, depending on the style of fighting and the level of training), has also become acute for researchers in recent years [12, 13, 14].

The study of the main aspects of improving training activity in MMA at the stage of specialized basic training (through an in-depth study of the ratio of parameters of volume and intensity of physical exertion) is an integral component of system optimization in this sport [3, 5, 8]. Despite a number of studies conducted with the aim of determining the optimal load regimes for MMA athletes, mechanisms for assessing the course of adaptive body changes at the stage of specialized basic training have been partially described. We should note that in order to achieve success in competitive activity an athlete will need to maximize not only the level of explosive power development, but also strength endurance depending on the opponent's fighting style. The conditions of fighting tactics require increasing the adaptive body reserves of athletes, which will allow to compensate for the energy expenditure during muscular activity of different duration and power [15, 16].

The purpose of this research is to study the peculiarities of influence of different intensity power load regimes on the functional capabilities of Mixed Martial Arts athletes in the process of training activity optimization at the stage of specialized basic training.

Materials and Methods

Participants

We examined 75 athletes (men) aged 19±0.7 who had been practicing MMA for 4±0.8 years. To achieve the purpose of the study, we divided the athletes into 3 groups, 25 participants in each group. The 1st and 2nd group representatives used anaerobic-glycolytic mode of energy supply for power loads in conditions of low (R_a=0.53) and medium (R_a=0.65) intensity. Athletes of the 3rd group used loads of high (R_a=0.72) intensity in the conditions of the anaerobic-alactate mode of energy supply.

The experimental study was approved by the ethical committee for biomedical research of Lesya Ukrainka Volyn National University in accordance with the ethical standards of the Declaration of Helsinki. Participants gave written informed consent for the research in accordance with the recommendations of the biomedical research ethics committees [17]. During the study, control of functional parameters, biochemical blood indicators in athletes of the examined groups took place in the medical center of the university using appropriate diagnostic equipment.

Research Design

Maximal muscle strength

We evaluated the maximum strength (1 RM) development in athletes of all examined groups using the method of control testing. The duration of the study was 12 weeks. Control of the studied indicators took place at the beginning of the experiment and after every 4 weeks of training while using different intensity load modes. To fulfill the tasks of the study the following exercises were used: bench press on the Smith simulator, block thrust behind the head, lying leg press. Machine exercises were used to ensure a reduction in injury cases and to clearly (without "cheating") determine the level of strength development. The strength exercises used during the study were performed in accordance with the generally accepted technique in power sports [2, 3, 18].

During strength training, the group participants used power load regimes of different intensity in the conditions of anaerobic-glycolytic and anaerobic-alactate energy supply of muscle activity. The study lasted 12 weeks. To assess the functional capabilities of athletes in these conditions we used methods of control testing of the maximum strength development (1 RM). Control of biochemical blood parameters (creatinine, lactate dehydrogenase, testosterone) allowed to determine the nature of adaptive and compensatory body reactions in response to power loads of various intensity.

Power load mode

Using the integral method of quantitative estimation of load capacity in power fitness [18] and the initial parameters of the maximum muscle strength (1 RM) development at the beginning of the study, we determined the load factor (R_a) and the intensity level of proposed by us power load regimes.

Biochemical parameters

In the process of biochemical blood control, we evaluated the activity of lactate dehydrogenase (LDH) and creatinine concentration in group participants by the kinetic method on the equipment of the company "High Technology Inc" (USA) with a set of PRESTIGE 24i LQ LDH reagents (Poland). Testosterone and cortisol concentration in the blood serum was determined by enzyme-linked immunosorbent analysis, using a set of reagents SteroidIFA-testosterone on the equipment of the company "Alcor Bio". Blood was taken from the vein of study participants by a medical worker before and after the training session at the beginning and at the end of 12 weeks of research in compliance with all norms [19].

Statistical analysis

Statistical analysis of the research results was performed using the IBM *SPSS*Statistics 26 program package (StatSoftInc., USA). Descriptive statistics methods were used to calculate the arithmetic mean and error of the mean. The non-parametric Wilcoxon test was used to assess the reliability of pairwise differences, and Friedman's ANOVA was used to analyze repeated measurements [20].

Results

Table 1 presents different levels of intensity of load regimes used by athletes of the examined groups in the process of strength training during the study. Using the integral method of quantitative estimation of load capacity in power fitness [18] and the initial parameters of the maximum muscle strength (1 RM) development, the quantitative indicators of repetitions in a set, the amplitude of movement, the duration of eccentric and concentric phases of movement, we estimated the load factor (R_a). This indicator (R_a) clearly reflects the level of intensity of power load regimes proposed by us. The duration of intense muscle activity in a set and the time allocated for recovery between sets allows making assumptions which regimes of energy supply were involved in training loads of different intensity.

The results presented in Table 2 reflect the nature of changes in the indicators of the maximum muscle strength (1 RM) development in 3 groups of study participants performing control exercises in conditions of using different intensity power load regimes.

The analysis of the results recorded during the study indicated that the average group indicators of strength capabilities development increased the participants of all examined groups. The most pronounced positive changes in the development of the maximum muscle strength indicator (by 49.2%; $p<0.05$) during the entire period of the study were found in athletes of the 3rd group during the exercise "lying leg press". At the same time, the least noticeable compared to the participants of the other groups, but reliable increase of the studied indicator (by 20.3%; $p<0.05$) was found in the athletes of the 1st group during the exercise "block thrust behind the head". The obtained results indicated that using high-intensity loads in conditions of the anaerobic-alactate energy supply regime contributed to the accelerated growth of maximum muscle strength.

The laboratory control of biochemical parameters of creatinine and testosterone concentration, lactate dehydrogenase activity in the blood serum of athletes of all three groups allowed determining the features of adaptive and compensatory reactions to low (R_a=0.53), medium (R_a=0.65) and high (R_a=0.72) training load intensity at different energy supply modes, and the patterns increasing the body functional reserves (Fig. 1, 2, 3).

The changes in creatinine concentration in the blood serum of the study participants, presented graphically in Figure 1, demonstrate a sufficiently different tendency of this indicator in response to loads of different intensity. Thus, in group 3 athletes who used high-intensity training loads in conditions of anaerobic-alactate regime of energy supply, the concentration of creatinine in the blood serum increased significantly both at the beginning (by 11.2%) and after 12 weeks of training (by 9.0%) in response to a stress stimulus. At the same time, the level of creatinine concentration in the blood serum of group 2 participants increased two times less

Table 1. Power load regimes used by MMA athletes in the process of strength training during the study

Intensity of power load regime	Peculiarities of power load regimes
Low intensity (R_a=0.53)	Anaerobic-glycolytic mode of energy supply for muscle activity. Full amplitude of movement with fixation at the peak point. The duration of a repetition is 4 seconds. 12 repetitions in a set. The maximum duration of work in a set is 48-55 seconds. Rest between sets lasts 60 seconds. The projectile working mass is 53-55% of 1RM.
Medium intensity (R_a=0.65)	Anaerobic-glycolytic mode of energy supply for muscle activity. Full amplitude of movement without fixation at the peak point. The duration of a repetition is 5-6 seconds. 8 repetitions in a set. The maximum duration of work in a set is 40-43 seconds. Rest between sets lasts 60 seconds. The projectile working mass is 65-67% of 1RM.
High intensity (R_a=0.72)	Anaerobic-alactate mode of energy supply of muscle activity. Partial (90%) amplitude of movement. The duration of a repetition is 8-9 seconds. 4 repetitions in a set. The maximum duration of work in a set is 32-35 seconds. Rest between sets lasts 45 seconds. The projectile working mass is 72-75% of 1RM.

Table 2. Changes in strength capabilities (1RM) results in study participants during 12 weeks of research, n=75

Exercises	Groups	Term of observation, weeks				χ^2, p df=3
		Initial data	4 weeks	8 weeks	12 weeks	
Bench press on the Smith simulator	1	64.10±1.54	71.96±1.54[1] Z=-4.3; p<0.05	78.98±1.52[1] Z=-4.4; p<0.05	80.96±1.40[1,2] Z=-4.1; p<0.05 Z=-4.4; p<0.05	χ^2=69.5 p<0.000
	2	63.48±1.50	74.59±1.46[1] Z=-4.2; p<0.05	83.42±1.53[1] Z=-4.4; p<0.001	86.12±1.45[1,2] Z=-3.8; p<0.05 Z=-4.4; p<0.05	χ^2=71.9 p<0.000
	3	61.90±1.54	74.62±1.65[1] Z=-4.4; p<0.05	83.70±1.37[1] Z=-4.4; p<0.001	85,90±1,38[1,2] Z=-3,5; p<0,05 Z=-4,4; p<0,05	χ^2=73.2 p<0.000
Block thrust behind the head	1	64.20±1.23	69.76±0.99[1] Z=-4.2; p<0.05	74.70±0.95[1] Z=-4.5; p<0.05	77.24±0.88[1,2] Z=-4.1; p<0.05 Z=-4.3; p<0.05	χ^2=73.6 p<0.000
	2	65.50±1.16	73.00±0.92[1] Z=-4.2; p<0.05	78.60±1.03[1] Z=-4.5; p<0.005	81.28±0.72[1,2] Z=-3.5; p<0.05 Z=-4.3; p<0.05	χ^2=72.6 p<0.000
	3	60.90±1.30	69.78±1.32[1] Z=-4.2; p<0.05	76.56±1.26[1] Z=-4.4; p<0.005	80.72±0.92[1,2] Z=-4.0; p<0.05 Z=-4.3; p<0.05	χ^2=73.4 p<0.000
Lying leg press	1	115.88±2.59	136.68±2.59[1] Z=-4.3; p<0.05	151.24±2.42[1] Z=-4.4; p<0.05	153.56±2.11[1,2] Z=-3.1; p<0.05 Z=-4.3; p<0.05	χ^2=69.5 p<0.000
	2	112.80±3.20	136.82±3.61[1] Z=-4.4; p<0.005	153.80±3.64[1] Z=-4.4; p<0.001	160.86±3.98[1,2] Z=-3.5; p<0.05 Z=-4.3; p<0.05	χ^2=73.2 p<0.000
	3	118.68±3.26	148.32±3.14[1] Z=-4.4; p<0.005	168.04±2.78[1] Z=-4.4; p<0.001	177,04±3,02[1,2] Z=-4.0; p<0.05 Z=-4.4; p<0.05	χ^2=73.9 p<0.000

Notes: [1] - the difference compared to the previous results is significant according to the Wilcoxon test (p<0.05); [2] - the difference compared to the initial values is significant according to the Wilcoxon test (p<0.05); df - is the number of degrees of freedom; p - is the level of significance.

than in group 3 athletes in response to the stimulus. However, the concentration of this biochemical indicator in the blood serum of the 1st group athletes showed positive but unreliable tendency to change. The most pronounced increase in the basal level of creatinine in the blood serum (by 19.2%; p<0.05) was fixed in group 3 athletes, who used loads of high (R_a=0.72) intensity in the conditions of the anaerobic-alactate regime of energy supply during the study.

Figure 2 shows the changes in LDH activity in the blood serum of the participants of all examined groups at rest and after exercise at the beginning of the study and after 12 weeks of training. The observation showed that the activity of the studied enzyme in the blood of group 1 athletes increased by an average of 31.0% (p<0.05) in response to medium-intensity training load in conditions of anaerobic-glycolytic mode of energy supply regardless of control stages. At the same time, the results of laboratory control indicated that LDH activity in the blood serum of group 3 athletes was almost 10 times lower compared to the data recorded in group 1 participants in response to high-intensity exercise in the conditions of anaerobic-alactate energy supply. The most pronounced increase in the basal level of LDH in the blood serum (by 14.6%; p<0.05) was observed in athletes of group 1. At the

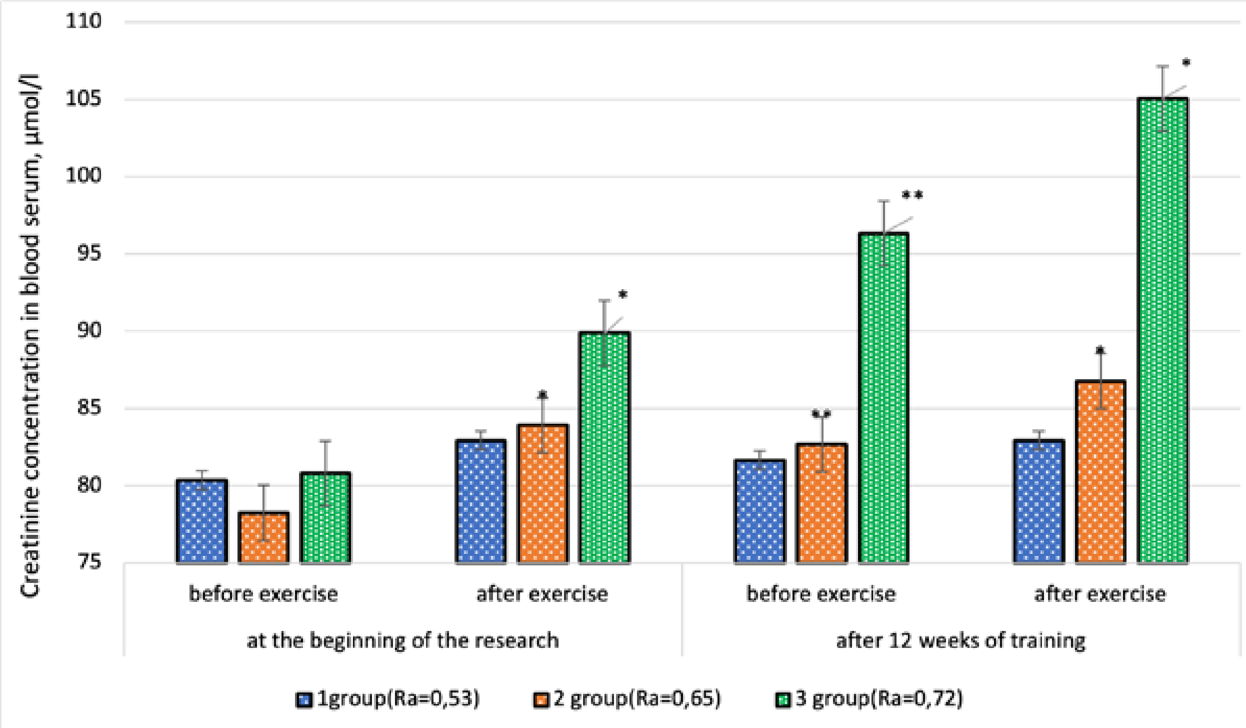

Figure 1. Changes in creatinine concentration in the blood serum of study participants during 12 weeks of training in the conditions of different intensity power load regimes, n=75

Note: * – p<0.05, compared to the indicators before the load; ** – p<0.05, compared to the indicators before the study

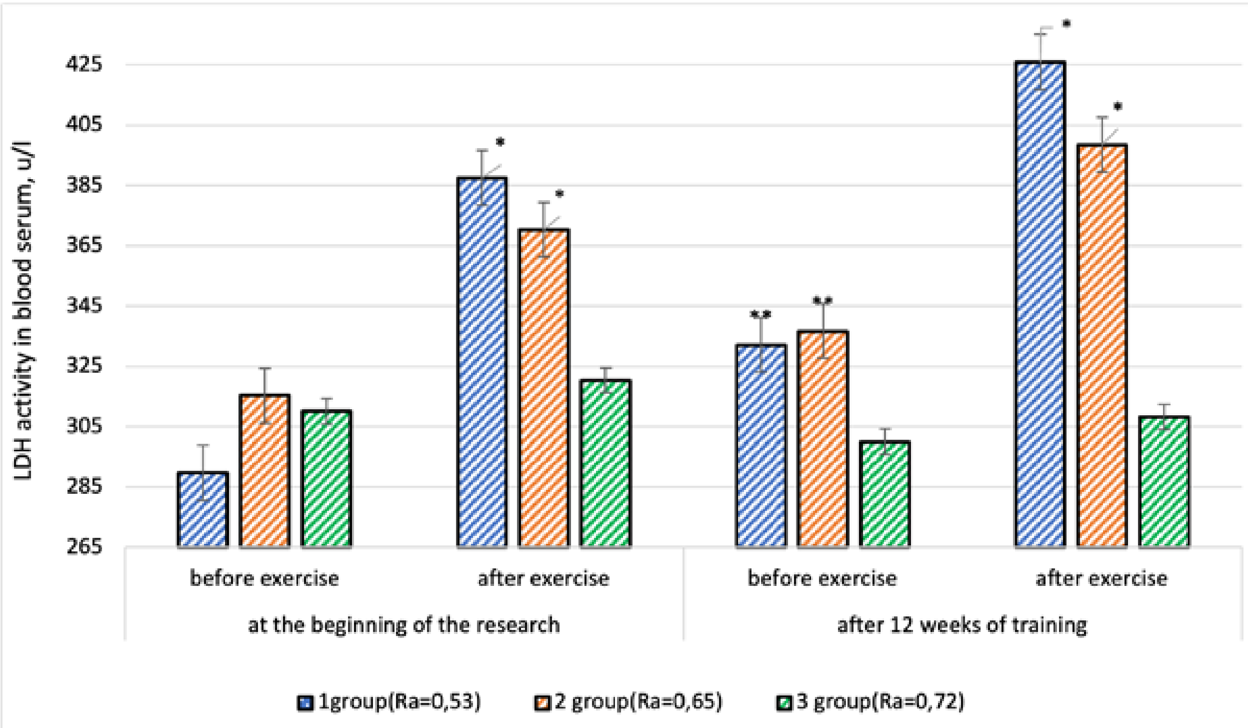

Figure 2. Changes in LDH activity in the blood serum of study participants during 12 weeks of training in the conditions of different intensity power load regimes, n=75

Note: * – p<0.05, compared to the indicators before the load; ** – p<0.05, compared to the indicators before the study

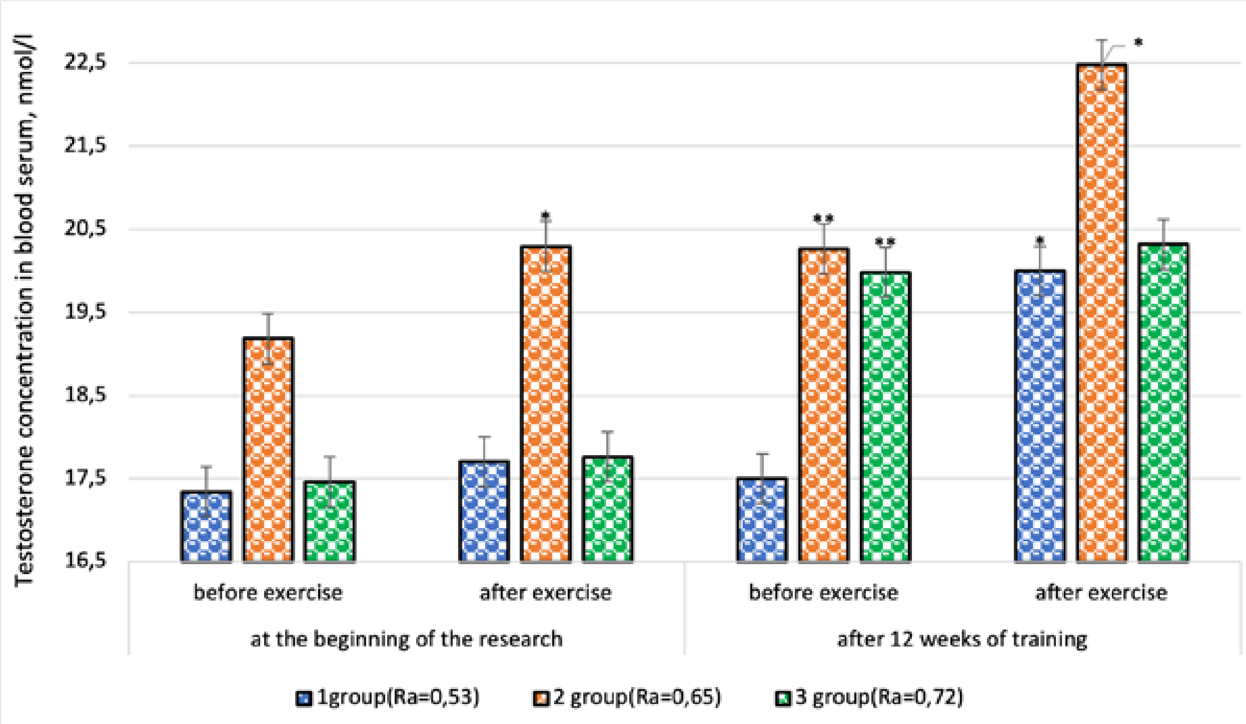

Figure 3. Changes in testosterone concentration in the blood serum of study participants during 12 weeks of training in the conditions of different intensity power load regimes, n=75

Note: * – $p<0.05$, compared to the indicators before the load; ** – $p<0.05$, compared to the indicators before the study

same time, the level of this biochemical indicator decreased by 3.2% in group 3 athletes compared to the data fixed at the beginning of the study.

We demonstrated the changes in testosterone concentration in the blood serum of research participants at rest and in response to power loads of different intensity and various energy supply mechanisms on Figure 3. The study showed that the greatest increase in the concentration of this steroid hormone in the blood serum (by 14.3%; $p<0.05$) was recorded at the end of the study in group 1 athletes in response to a physical stimulus. At the same time, the smallest change in this biochemical indicator (by 1.7%) was found in group 3 participants in response to high-intensity training loads. The most pronounced increase in the basal level of testosterone in the blood serum (by 14.4%; $p<0.05$) was fixed in group 3 athletes, whose muscle activity was provided at the expense of anaerobic-alactate energy supply systems. At the same time, the basal concentration of this steroid hormone in the blood serum of group 1 participants had almost no changes.

Discussion

The problem of determining a single complex of mechanisms for optimizing training regimes of loads in Mixed Martial Arts and effective ways of correcting their main indicators, taking into account the peculiarities of the physiological processes of adaptation, individual functional capabilities of athletes, is one of the priority issues not only of trainers, high-level professional fighters, but also of scientists [2, 8, 14, 16, 21]. Determining the most optimal parameters of the intensity of power load regimes at the stage of specialized basic training in MMA is one of the main directions of this problem [3, 8, 10] because it will allow to maximize the functional capabilities of athletes in the shortest possible time. An important aspect of improving the training process at this stage of training is the determination of the most informative markers for assessing adaptive and compensatory reactions to training loads in the conditions of anaerobic-alactate and anaerobic-glycolytic modes of energy supply of muscle activity during matches [7, 9, 10]. It is the use of indicators of laboratory diagnostics of the blood biochemistry of athletes, as the main criteria for assessing the need to correct load regimes, that scientists have been paying attention to in recent years [3, 8, 12, 22].

This research proved that using high-intensity loads in conditions of anaerobic-alactate mode of energy supply of muscle activity contributed to the most accelerated growth of the maximum strength indicator (1 RM) and the functional capabilities of the body on the whole. We suppose that these changes are associated with an increase in the number of moving units in the working muscles and improvement of intermuscular coordination due to the peculiarities of the load regime proposed by us (R_a=0.72) [3, 8].

The results of basal level of creatinine and testosterone concentration in the blood serum indicated their significant increase, especially in the conditions of the anaerobic-alactate mode of energy supply. The changes in biochemical blood markers indicate an increase in the adaptive reserves of the body and an increase in muscle mass [6, 7], which contributes to the maximum increase in the strength capabilities of athletes and their level of functional training. At the same time, the increase in LDH activity in the blood serum of athletes in response to medium and low-intensity training load in conditions of the anaerobic-glycolytic mode of energy supply indicates a significant accumulation of lactate, the manifestation of compensatory reactions and, subsequently, a decrease in the activity of muscle activity [12, 15].

Conclusions

Using high-intensity power loads (R_a=0.72) by MMA athletes in conditions of predominantly anaerobic-alactate energy supply at the stage of specialized basic training contributes to the most accelerated increase in the body functional capabilities and the growth of maximum muscle strength indicators. However, the optimal conditions for using this level of strength capabilities and their most effective implementation occur during attacking or counter-attacking actions of athletes during competitions. Using medium-intensity loads (R_a=0.65) in the training activity will contribute to expanding the necessary adaptation reserves and increasing functional capabilities due to the duration of muscle tension during fights in a ring.

Determining the peculiarities of changes in the biochemical blood parameters (creatinine, LDH, testosterone) of the athletes in response to a stress stimulus of the appropriate intensity will allow in the shortest possible time to optimize the load regimes due to the correction of its main components while improving strength training in MMA.

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Conflict of interest

No potential conflict of interest that is of any relevance to this study was reported by the authors.

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ORIGINAL ARTICLE

Functional readiness and properties of the nervous system peculiarities of art specialties' future teachers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The future professional work of students of the Faculty of Arts is characterized by an insufficient level of physical activity of a dynamic nature in combination with a large static load and highly coordinated finger work. Representatives of these specialties have their own psychological characteristics. Purpose: to reveal the peculiarities of the properties of the nervous system and the functional potential of the cardiovascular system of students - future teachers of fine arts and music and, based on the obtained data, to develop recommendations for physical education and sports.

Material and Methods Students of Pedagogical University took part in the study. The total number of students was 812. 24 of them were students of the Faculty of Arts. Future specialists in physical education and sports took part in the number of 25 people. 763 students were representatives of other faculties. Properties of the nervous system were determined using psychophysiological testing. During psychophysiological testing, the reaction time and the number of errors were determined for each test. The indicators of the orthostatic test were used as indicators of functional readiness. In the orthostatic test, the heart rate was measured in the lying position and in the standing position and the difference between these indicators. Statistical analysis involved comparing students of the Faculty of Arts with students of other faculties using parametric methods, since all samples corresponded to a normal distribution.

Results Future teachers of creative specialties have reliably the least mobility in combination with the highest stability of nervous processes in comparison with representatives of other pedagogical specialties. Reliable differences were found between the indicators of orthostatic reactions of students of the Faculty of Arts and the faculty where future sports coaches are trained. Orthostatic regulation is significantly better in students of the Faculty of Physical Education and Sports.

Conclusions It is necessary to adjust the program of physical education of students of creative specialties to increase the interest of students and to match physical exercises to the features of the nervous system of students of the Faculty of Arts. Future teachers of creative specialties can be recommended to engage in any kind of sport or motor activity, but the most suitable for them are exercises that require the development of endurance in combination with the inclusion of cognitive processes and concentration: walks with observation of nature and the city, exercises performed to music, exercises with a concentration on various natural images, etc.

Keywords: students, orthostatic test, psychophysiological functions

Introduction

The formation of a healthy lifestyle of future teachers is of great importance for society [1, 2, 3, 4]. As the great teacher of the 20th century, Maria Montenssori [5], pointed out, the future teacher must, first of all, be attractive to children. At the first stage, attractiveness for children is determined by the appearance of the teacher. And in order to have a good appearance, you need to have good health [6]. In addition, future teachers must overcome all the difficulties of studying at the university. Also, their future work is associated with psychological and physical stress [1, 2]. After all, they will need to effectively interact with children, with parents, with the leadership of the school and education in general, prepare for classes, have time to work with documentation and pay attention to their own family. And most importantly, teachers bring knowledge to future generations. And they also need to convey knowledge about a healthy lifestyle to their students and form in them the skills and abilities to strengthen and preserve health. Only in this way can a healthy nation be formed.

Specialists in creative specialties occupy a special place among future teachers. In general, pedagogy requires creativity. But in society, creative specialties include music, visual arts, and dance. We will look at health-saving technologies for musicians and

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artists. Their professional work is characterized by an insufficient level of physical activity of a dynamic nature in combination with a large static load and highly coordinated work of the fingers [7, 8, 9, 10]. Representatives of these specialties have their own psychological characteristics. First of all, they have developed creative thinking with imaginative perception and activation of the right hemisphere of the brain [9]. This is of great importance for the creation of world-class masterpieces, but it provides certain characteristics. This is reflected in the fact that they can, for example, be engaged in a creative project all the time. At the same time, they can forget about anything, even about food and sleep. And all the more they forget about doing physical exercises, which is a necessary condition for a healthy lifestyle [7, 10]. That is why it is necessary for them to choose physical exercises and technologies of physical education in such a way that they are organically combined with art classes and very appealing to future specialists in creative specialties. And this is not accidental. After all, art seeks constant creative improvement.

It should be noted that people at all times sought the unity of physical, intellectual and physical development. So, the great mathematician, philosopher, humanist Pythagoras was the champion of the Olympics in Greece in fist fighting and an innovator in music [8, 10]. And the famous swordsman Miyamoto Musashi [11] pointed out that a real warrior should get acquainted with every kind of art and learn the ways of all professions. This is not accidental, because the possession of a wide range of movements affects the coherence of the work of the central nervous system [12, 13, 14]. That is why athletes need to study the basics of art, and future specialists in creative specialties need to improve their control of their bodies through physical exercises.

The physiological basis of the unity of sport and art is that all levels of the central nervous system participate in the process of controlling movements and forming skills [12, 13]. Therefore, with the development of the perception of beauty and harmony, be it sports movements or works of art, the coherence of the work of the central nervous system is improved. It helps to achieve excellence in all activities. In this connection, art and sport are a single entity.

In our previous studies [15], we established by analyzing specific examples that sport and art have many common features. Both sports and art require motor activity. In sports, these are movements of large muscles, in art - movements of small muscles. Sports and art require a perfect mastery of movements that exceeds generally accepted averages. Ideal technique determines the most rational movements, which are perceived as beautiful. Perception of art develops creativity, non-standard thinking. So, there is a connection between sports and art that promotes the manifestation of mastery. It is not by chance that many famous actors, musicians, and artists combine art and sports

Let's consider the need to combine art and sports on the example of training musicians. In order to successfully study at a music school, it is necessary to study for 2 hours every day, and in the process of improvement - for 4-6 hours or more [7, 8, 9, 10]. Classes are accompanied by large static loads on the spine, pelvic muscles and lower limbs with high dynamic loads on the muscles of the shoulder girdle. Performances at competitions and concerts also require a high level of endurance and mental stability. Many types of musical art require a high level of physical training. For example, to achieve a good sound on wind instruments, it is necessary to develop the strength of the respiratory muscles. Unfortunately, many young talents do not realize their potential due to insufficient level of health. Therefore, physical exercises are necessary for musicians as an integral means of their professional training. And their teachers should promote sports.

These provisions also apply to all other creative specialties. That is why it is necessary to choose such classes in physical culture and sports, which would be organically combined with the main type of activity, and help to improve in the chosen art form.

To solve the tasks, it is necessary to determine the peculiarities of the functioning of the nervous system of future specialists in creative specialties. The most accessible way of determining the features of the nervous system is based on psychophysiological indicators: reaction speed in different testing conditions and the number of errors when passing these tests [13, 14]. These indicators reflect the mobility and stability of nervous processes. It is also important to determine the functional features of the cardiovascular system and the regulation of vascular tone [16, 17, 18, 19]. This is necessary to determine the impact of lack of physical activity on orthostatic regulation. Orthostatic regulation is a necessary condition for the quality work of a specialist in creative specialties, who, due to the peculiarities of their work, need to spend a lot of time in a standing position.

In our research, the following hypothesis was put forward: students - future teachers of creative specialties have peculiarities of psychophysiological functions and orthostatic reactions in comparison with students of other specialties of pedagogical universities.

Purpose: to reveal the peculiarities of the properties of the nervous system and the functional potential of the cardiovascular system of students – future teachers of fine arts and music and, based on the obtained data, to develop recommendations for physical education and sports.

Material and Methods

Participants

Students of H.S. Skovoroda Kharkiv National Pedagogical University took part in the study. The total number of students was 812. 24 of them were students of the Faculty of Arts. Future specialists in physical education and sports took part in the number of 25 people. Also, 88 future specialists - teachers of junior grades, 76 - future teachers of history, 130 - future teachers of mathematics, physics, biology disciplines took part in the study. Future foreign language specialists took part in the number of 131 students. 93 representatives of preschool education, 198 future Ukrainian language teachers, and 25 future sports coaches also took part in the study. 47 participants of the experiment were representatives of psychological and sociological specialties.

Research Design

The testing procedure was similar to that described in our previous studies [1, 2].

The method of determining the properties of the nervous system

The determination of the peculiarities of the work of the nervous system was carried out according to the author's psychophysiological testing program [1, 2, 13, 14]. We determined the speed of a simple reaction when you need to press the left mouse button on any picture that appears on the computer screen. The number of errors was also determined in this test. The speed of reaction and the number of errors in the test for a complex discrimination reaction were also determined. The choice of two elements from three options was assumed. Different pictures appeared alternately on the computer screen. If the picture had an image of a geometric shape, you had to press the left mouse button. If an image from the animal world appeared on the computer screen, you had to press the right mouse button. All other images were to be skipped without clicking. When determining the properties of the nervous system, we used the following provisions: the faster the student reacts to the object, the higher the mobility of the nervous system; the fewer mistakes he makes, the greater the stability of his nervous system [1, 2, 13, 14].

Determination of functional capabilities of the cardiovascular system and regulation of orthostatic functions

To determine the functional capabilities of the cardiovascular system, we used the heart rate indicator in the supine position. The lower this indicator was (up to 48-44 beats per minute), the more economically the heart works [6, 16, 19]. We also determined the frequency of heart contractions after the transition from a lying position to a standing position. The smaller this value was, the more developed the mechanism of vascular tone regulation when changing the position [6, 17, 19].

Statistical analysis

First of all, we checked the samples for normal distribution according to standard methods [1, 2]. In our case, all samples obeyed a normal distribution ($p>0.05$), and therefore we used parametric methods of processing the results (Student's test). We compared the results of the tests based on psychophysiological indicators and on indicators of orthostatic reactions of students of the Faculty of Arts and students of all other faculties of the Pedagogical University. We also compared students of the Faculty of Arts and students of the Faculty of Physical Education and Sports to identify the impact of sports on selected indicators.

Results

We found reliable differences in the results of the tests of students of the Faculty of Arts and all other faculties of the pedagogical university in only two indicators of psychophysiological functions: the time of a simple visual-motor reaction and the number of errors in the test for the time of a complex reaction to the selection of different images. Students of the Faculty of Arts have a significantly longer latent time of a simple visual-motor reaction ($p<0.05$) and a significantly lower number of errors in the complex reaction time test (Table 1, Fig. 1, 2).

The speed of reaction characterizes the mobility of the nervous system. An increase in reaction time indicates a decrease in the mobility of nervous processes. Therefore, it can be noted that the students of the Faculty of Arts have a less mobile nervous system in comparison with students of other faculties. Also, the smaller number of errors in the reaction time test for choosing 2 elements out of 3 indicates greater stability of the nervous system of students of the Faculty of Arts in comparison with other faculties of the Pedagogical University.

It should be noted that in the processing of the results in the tests on the number of errors in the test of a complex reaction to the choice of two options out of three and in the orthostatic test, the data of the Faculty of Physical Education and Sports were not included. As we found in our previous studies [2], students of this faculty showed the lowest values of the measured indicators. We excluded them from the analysis in order to discover whether students in the Faculty of Arts differed from those in other non-sporting faculties. The same applies to the comparison of the results of orthostatic reactions (Table 1, Fig. 2).

According to all other indicators, no significant differences were found between the test results of students of the Faculty of Arts and students of all other faculties of the Pedagogical University ($p>0.05$) (Table 1).

To determine the influence of sports on the

Table 1. Indicators of properties of the nervous system and functional capabilities of the cardiovascular system of students of the Faculty of Arts in comparison with students of other faculties

Indicators	Faculties*	N	x̄	S	m	t	p
Reaction time without selecting images, ms	1	788	391.280	105.333	6.434	-2.218	0.027
	2	24	509.500	141.262	70.631		
Errors in the reaction time test without selecting images, number	1	788	2.338	5.673	0.347	0.207	0.836
	2	24	1.750	1.500	0.750		
Complex reaction time for choosing two options out of three, ms	1	788	515.059	140.775	8.816	0.107	0.915
	2	24	507.500	66.083	33.042		
Errors in the test for the time of a complex reaction to the choice of two options out of three, number	1	763**	7.954	11.066	0.841	6.382	0.000
	2	24	1.250	1.258	0.629		
Heart rate lying down, beats·min^{-1}	1	763**	72.130	10.544	0.967	-0.354	0.724
	2	24	74.000	2.828	1.414		
Standing heart rate, beats·min^{-1}	1	763**	89.540	12.817	1.175	-0.924	0.357
	2	24	95.500	5.508	2.754		
The difference between the heart rate standing and the heart rate lying down, beats·min^{-1}	1	763**	17.310	11.032	1.011	-0.754	0.452
	2	24	21.500	5.745	2.872		

Notes. * 1 – all faculties that were studied; 2 - Faculty of Arts. ** Data from the faculty of physical education and sports were not included in the processing of the results in the tests for the number of errors in the test of a complex reaction to the choice of two options out of three and in the orthostatic test, since the students of this faculty showed the lowest values of the measured indicators

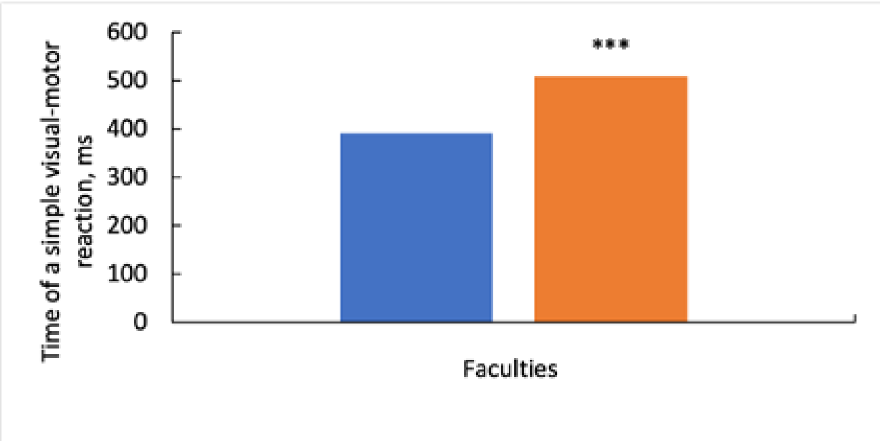

Figure 1. The value of the time of a simple visual-motor reaction in students of the Faculty of Arts in comparison with students of other faculties:

*** - differences are significant at $p<0.001$

- all faculties; - Faculty of Arts

indicators of psychophysiological functions and orthostatic reactions, we compared these indicators among students of the faculties of arts and physical education and sports. The presence of reliable discrepancies was found only for the indicators of orthostatic reactions (Table 2, Fig. 3). The frequency of heart contractions in the lying position is significantly higher in students of the Faculty of Arts compared to students of the Faculty of Physical Education and Sports. This indicator is equal to 62 bpm for students of the Faculty of Physical Education and Sports and 74 bpm for students of the Faculty of Arts ($p<0.05$) (Table 2, Fig. 3).

The same applies to the heart rate indicator in a standing position: this value is significantly higher in students of the Faculty of Arts compared to students of the Faculty of Physical Education and Sports ($p<0.01$). The difference between heart rate in the standing position and in the lying position is also significantly higher in students of the Faculty of Arts compared to students of the Faculty of Physical Education and Sports ($p<0.05$) (Table 2, Fig. 3).

The obtained data indicate that sports have a positive effect on the functional state of the

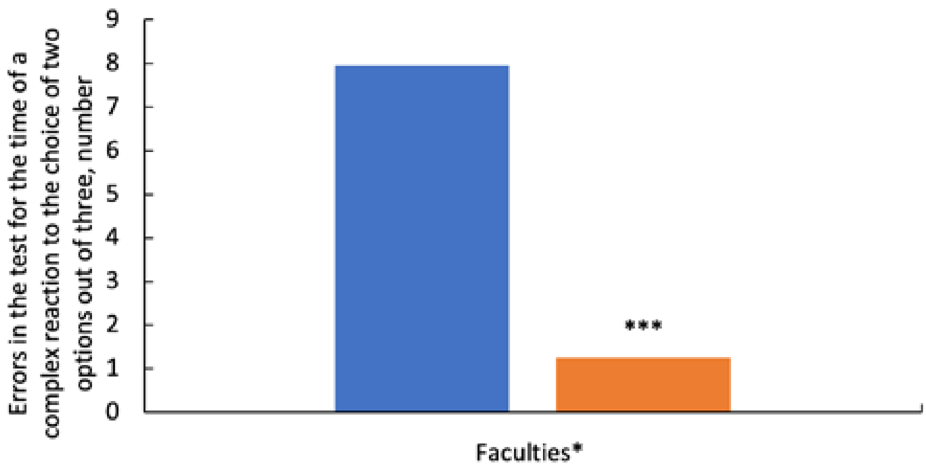

Figure 2. The number of errors in the test for the time of a complex reaction to the choice of two options out of three among students of the Faculty of Arts in comparison with students of other faculties:

* the data of the Faculty of Physical Education and Sports were not included in the processing of the results, since the students of this faculty showed the least number of errors in this test

*** - differences are significant at $p<0.001$

- all faculties; - Faculty of Arts

Table 2. Indicators of properties of the nervous system and functional capabilities of the cardiovascular system of students of the faculties of arts and physical education and sports

Indicators	Faculties*	N	x̄	S	m	t	p
Reaction time without selecting images, ms	1	25	403.750	152.450	76.225	-1.018	0.348
	2	24	509.500	141.262	70.631		
Errors in the reaction time test without selecting images, number	1	25	4.750	8.221	4.110	-0.434	0.680
	2	24	8.250	13.889	6.945		
Complex reaction time for choosing two options out of three, ms	1	25	519.750	72.006	36.003	0.251	0.810
	2	24	507.500	66.083	33.042		
Errors in the test for the time of a complex reaction to the choice of two options out of three, number	1	25	2.000	0.817	0.408	1.000	0.356
	2	24	1.250	1.258	0.629		
Heart rate lying down, beats·min^{-1}	1	25	62.250	6.652	3.326	-3.251	0.017
	2	24	74.000	2.828	1.414		
Standing heart rate, beats·min^{-1}	1	25	73.750	7.042	3.521	-4.866	0.003
	2	24	95.500	5.508	2.754		
The difference between the heart rate standing and the heart rate lying down, beats·min^{-1}	1	25	11.500	3.786	1.893	-2.907	0.027
	2	24	21.500	5.745	2.872		

Note: * 1 – Faculty of Physical Education and Sports, 2 – Faculty of Arts

cardiovascular system and the regulation of vascular tone.

Discussion

The hypothesis, which was put forward in this study, was confirmed regarding the existence of peculiarities of the work of the nervous system according to the indicators of psychophysiological functions of future teachers of creative specialties. It was found that their reaction speed is lower compared to representatives of other specialties. This indicates that the future specialists of creative specialties have lower mobility of nervous processes. At the same time, students of the faculty of arts have a significantly lower number of errors in the test for determining the reaction time of choosing 2

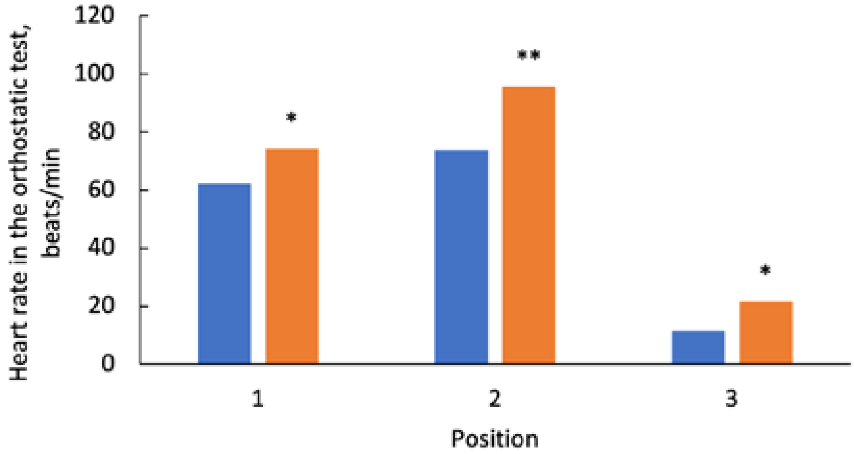

Figure 3. The value of heart rate in the orthostatic test of students of the Faculty of Arts in comparison with the Faculty of Physical Education and Sports: 1 – in the lying position, 2 – in the standing position, 3 – the difference in heart rate between the standing position and the lying position

* - differences are significant at p<0.05

** - differences are significant at p<0.01

- Faculty of Physical Education and Sports; - Faculty of Arts

elements out of 3 compared to students of all other studied students - future teachers.

This indicates that future specialists in creative specialties have a higher stability of the nervous system compared to other future teachers [2, 13, 14]. Exceptions are made only by students of the Faculty of Physical Education and Sports. Their number of errors is the lowest among all the experimental students [1]. And this shows that the students of the Faculty of Physical Education and Sports have the greatest stability and strength of the nervous system. Among students of the faculty of arts, the number of errors in the choice reaction test is unreliably different from this indicator of students of the faculty of physical education and sports.

And therefore, we can conclude that students - future teachers of creative specialties are distinguished by low mobility of nervous processes combined with great stability of the nervous system. We can explain this fact by the fact that the specificity of the work of representatives of visual arts and music requires long-term concentration on the canvas they create, or on learning a certain piece of music, which can last several hours every day. Thus, the peculiarities of the nervous system of students of the Faculty of Arts are the ability to concentrate for a long time when it is necessary to do something without mistakes and not to switch attention to other matters. This is due to such properties of the nervous system as high stability (strength) and low mobility of nervous processes [1, 2, 13, 14]. We do not consider the question whether these features of the nervous system of creative specialties' future teachers are hereditary or they are formed in the process of creative activity.

It is known that the properties of nervous systems are largely hereditary, but can be developed in a certain range [13, 14]. We can note that creative specialties are intuitively chosen by people who have hereditary prerequisites from the side of the properties of the nervous system. And the question arises: what physical exercises are most suitable for future specialists in creative specialties? We believe that the most rational will be exercises that also require a long-term moderate load. At the same time, physical exercises should bring satisfaction to future teachers of creative specialties. Walks and trips deserve special attention [20, 21]. After all, they correspond to the peculiarities of their nervous system, that is, they also require great stability. In addition, these exercises develop endurance, and, accordingly, the cardiovascular system - the main factor of health. During walks, you can observe the beauty of nature or the city. It is most suitable for representatives of creative specialties as appreciators of beauty. It should also be noted that in almost all types of sports and motor activity there are representatives with any properties of the nervous system. After all, the nervous system is capable of adaptation. That is why future teachers of creative specialties can engage in various types of aerobics [22], active and sports games, cycle sports, etc. [23]. Thus, future teachers of creative specialties can be recommended to engage in any kind of sport or motor activity, but the most suitable for them are exercises that require the development of endurance in combination with the inclusion of cognitive processes and concentration: walks with observation of nature and the city, exercises performed under music, exercises with concentration on various natural images, etc.

Conclusions

1. Future teachers of creative specialties have reliably the lowest mobility in combination with the highest stability of nervous processes in comparison with representatives of other pedagogical specialties. These features of the nervous system of future teachers of creative specialties can be hereditary or formed in the process of creative activity. They determine the application of physical exercises, which are most suitable for future specialists in creative specialties.

2. Significant differences between the indicators of orthostatic reactions of students of the Faculty of Arts and the Faculty of Physical Education and Sports were revealed. Orthostatic regulation is significantly better in students of the Faculty of Physical Education and Sports.

3. It is necessary to adjust the program of physical education of students of creative specialties to increase the interest of students and to match physical exercises to the peculiarities of the nervous system of students of the Faculty of Arts. Future teachers of creative specialties can be recommended to engage in any kind of sport or motor activity, but the most suitable for them are exercises that require the development of endurance in combination with the inclusion of cognitive processes and concentration: walks with observation of nature and the city, exercises performed to music, exercises with a concentration on various natural images, etc.

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Conflict of interest

The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

The influence of the ethno-territorial factor on the state of physical abilities development of students of Ukrainian educational institutions

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The development of motor skills depends on the process of physical development, as well as the ethno-territorial and cultural context. The study of inter-ethnic differences can provide information about how different lifestyles and contexts of physical activity can influence the process of motor competence development. This can be a real strategy for developing students' lagging basic motor skills. The purpose of the work is to investigate the ethno-territorial variability of the level of development of physical abilities of students studying at Ukrainian universities.

Material and Methods Data were obtained from cross-sectional surveys from 2014 to 2019. Students of Ivano-Frankivsk National Medical University (Ukraine) (young men, n = 488, age 18–25) from different countries were recruited. Pedagogical testing was carried out using a battery of tests that were recommended by the State Tests of Physical Fitness of the Population of Ukraine and the European Sports Council (Evrofit Test Battery). Assessment of physical fitness of students was carried out on the basis of a combined percentage scale of multi-level gradation with a step of 1%. Experimental data were processed using the SPSS Statistics 17.0 program.

Results In almost all countries (with the exception of India and Tunisia), from 41.2% to 70.0% of students are characterized by a low level of development of cardiorespiratory endurance and speed-power fitness (from 54.4% to 58.3%). More than 50.0% of students from Jordan and Egypt have a low level of speed and strength abilities and flexibility. It was found that students from India and Tunisia have the highest rates (endurance - 75.5–80.8%); from China and Tunisia (speed-power abilities - from 69.1% to 78.8%); from Tunisia (speed –79.8%); from China and Tunisia (flexibility -70%); test participants completed the test; from China (power capacity – 76.7%). Students from European countries showed mostly average and above average level of development of physical abilities.

Conclusions The results of the study indicate the specificity of the development of motor skills of students from different countries, which is manifested in statistically significant differences in the results of test tasks. Students from different countries perform better on those tests that are closer to their known motor experience. This is due to the cultural environment, geographical factor, socio-economic status, as well as the content and goals of the physical education program.

Keywords: physical fitness, ethno-territorial factor, population, students.

Introduction[1]

Recent studies show a decline in physical activity in society as a whole. Moreover, the most significant regression occurs among students who graduate from schools and those who enter universities [1, 2, 3]. As a result, there is a significant decrease in the level of physical development and physical abilities [4, 5]. It should be noted that in the scientific literature there are many studies of the motor activity of student youth from different countries of the world [6, 7, 8, 9, 10] and also directions of its intensification [11].

As for foreign students, according to the studies of a number of scientists, their level of physical activity is low [12, 13, 14, 15]. According to a WHO study, physical inactivity among adults is highest in Eastern Mediterranean, America, Europe, and the Western Pacific region, and the lowest in Southeast Asia [16, 17]. In the study by Suminski et al. [18] is compared physical activity patterns among Asian, African American, White and Hispanic American

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students. The authors found that 46.7% of students were not engaged in intensive physical activity and 16.7% were physically inactive.

A small amount of research was devoted to the problem of analyzing differences in the level of development of individual physical qualities. In the study by Adeyemi-Walker et al. [19] black and white ethnic groups achieved significantly better mastery of motor skills compared to Asian children of the same age. Another study [20] also indicated differences in the level of mastery of motor skills between students from countries of Africa, Turkey, Iran, Ukraine and a number of European countries. Differences in the development of fundamental motor skills are also emphasized in the work of Bardid et al. [21].

Such differences in individual characteristics of the level of development of motor skills are explained by differences in physical development [22, 23], cultural environment [24, 25, 26, 27], geographical factor [28], socio-economic status [29, 30, 31], an opportunity to practice skills [18, 22, 32, 33, 34]. However, these studies are stochastic in nature, dispersed in time, and use different test instruments.

The aim of the work. To investigate ethno-territorial variability in the development of physical abilities of students studying at Ukrainian universities.

Materials and Methods

Participants

Students (young men, n = 488, aged 18–25) from 9 countries of the world participated in the study (Table 1). All students agreed to participate in the experiment. The research protocol was approved by the Biomedical Ethics Commission of the Ivano-Frankivsk National Medical University (Ukraine, protocols № 85177 dated 10.24.2014, № 89198 dated 10.22.2015, №92850 dated November 23, 2016, №96311 dated October 24, 2017 and №112/19 dated 12.24.2019).

Research Design

Datum was from cross-sectional surveys since 2014 through 2019 on the basis of Ivano-Frankivsk National Medical University (Ukraine) during 2014–2019. Pedagogical testing was carried out using a battery of tests that were recommended by the State Tests of Physical Fitness of the Population of Ukraine [35]. The structure of pedagogical testing is given in table 2.

The assessment of physical fitness of students is based on a combined percentage scale of multi-level gradation with a step of 1%. This scale is superimposed on a traditional 5-level rating scale based on benchmarks (reference points): a high level corresponds to a scale value of 100%,

Table 1. Distribution of study participants

Country	n
Poland	45
Bulgaria	62
Malaysia	34
India	41
Jordan	68
China	38
Egypt	26
Tunisia	35
Ukraine	49
Totals	488

Table 2. Structure of the pedagogical testing system

Abilities for testing	Assessing characteristics	Test content
General duration	Cardiorespiratory duration	Running, 1000 m (min., sec.)
Maximum strength	Speed strength	Standing Long Jump Test (Broad Jump), cm;
	Dynamic strength	Pull-Up Bars number
Speed	Running speed	Running, 30 m (s)
Agility		4x9 m Shuttle test, sec.;
Elasticity	Mobility of the spinal column	Seated Forward Bend, cm;

an average value of 70%, and a low value of 50%. For the comparability of the results, it is possible to interpret the calculated data in the generally accepted 5-level rating system (Fig. 1).

Statistical analysis

Student's t-tests for independent samples were used to assess differences in continuous variables between men in the different ethnic groups. Pearson's chi-square analyzes were used to identify differences in the proportion of participants from each group depending on fitness level. Based on the Kolmogorov-Smirnov test we considered the data normally distributed. Data are presented as mean and standard deviation (SD).

Results

The results of testing the level of development of physical abilities of students (young men) are presented in the table 3. It was found that the average values of general or cardiorespiratory endurance for students are mostly at above average, average and below average levels. Although the frequency ratio of young men regarding the levels of general endurance is different (Fig. 2).

As can be seen from figure 2, that in almost all countries (with the exception of India and Tunisia) 41.2 - 70.0% of students are characterized by low indicators of cardiorespiratory or general endurance. This indicates a deficit in the development of this ability. For the representatives of India and Tunisia, the shares of such students are in the range of 19.2–24.5%.

The level of speed and strength training based on the results of standing long jump testing is presented in figure 3.

The values of the results of the speed-power fitness test show that the largest variations in the studied parameter are observed between representatives of Tunisia and China. Among these students, 20.2% to 30.9% of the participants failed the test. Students from Asian-African countries have the lowest results - from 54.4% to 58.3% of

Level of physical training					Assessment level
High	Above average	Average	Below average	Low	qualitative
100% and more	85-99%	70-84%	51-69%	50% and below	Percentage
5 points	4 points	3 points	2 points	1 points	points

Basic (optimal) level
(the test completed)

Deficit of development of abilities
(the test is not completed)

Figure 1. Structural diagram of the rating scale of physical fitness

Table 3. Indicators of physical fitness of students,

Country	Indicators: Running, 1000 m; min., sec	Standing Long Jump (Broad Jump), cm	Pull-Up Bars number	Running, 30 m; sec	4x9 m Shuttle test, sec.	Seated Forward Bend, cm
Poland	4.13(1.10)	220.2(22.4)	12.0(1.2)	5.21(0.82)	9.30(0.92)	11.2(3.7)
Bulgaria	4.12(1.02)	231.5(19.4)[1]	11.9(1.0)	5.05(0.40)	9.35(1.05)	10.8(4.2)
Ukraine	4.10(0.78)	230.2(20.2)[1]	12.4(0.8)[2]	4.95(0.61)	9.04(0.89)	11.8(3.5)
Malaysia	4.25(1.03)	207.5(21.2)[123]	9.8(1.4)[123]	4.94(0.93)	10.02(0.81)[123]	11.0(3.8)
India	4.08(0.92)	214.6(16.5)[23]	10.0(1.6)[123]	5.25(0.79)	10.12(0.76)[123]	12.1(2.3)[2]
China	4.27(1.12)	225.8(12.7)[45]	13.5(2.1)[12345]	4.91(1.00)	9.04(0.52)[45]	12.3(2.1)[2]
Jordan	4.35(1.32)	218.4(14.2)[2346]	9.8(2.5)[1236]	5.63(0.89)[123456]	10.14(1.42)[1236]	10.1(3.6)[356]
Egypt	4.35(0.82)	216.9(21.3)[23]	10.2(2.0)[1236]	5.71(1.05)[12346]	10.71(0.53)[1234567]	10.4(4.0)[6]
Tunisia	4.01(0.45)	226.4(19.2)[457]	11.3(1.4)[12345678]	4.78(0.98)[1578]	9.14(0.94)[4578]	12.9(3.2)[12478]

Note: statistically significant difference (p <.05) between data of students from: 1 – Poland and others; 2 – Bulgaria and others; 3 – Malaysia and others; 4 – India and others; 5 – Jordan and others; 6 – China and others; 7 – Egypt and others; 8 – Tunisia and others (based on t-test)

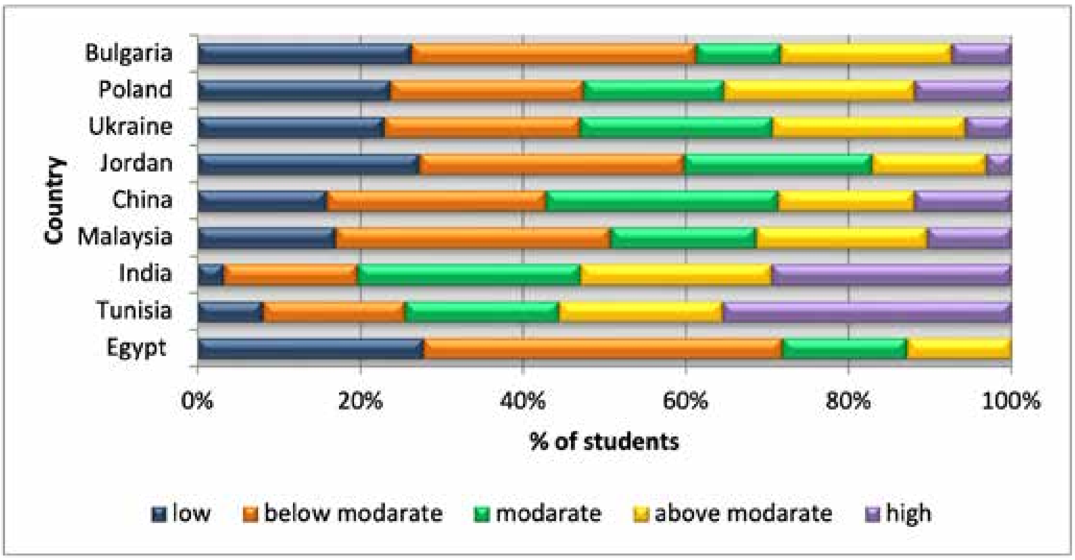

Figure 2. Distribution by levels of cardiorespiratory endurance of students

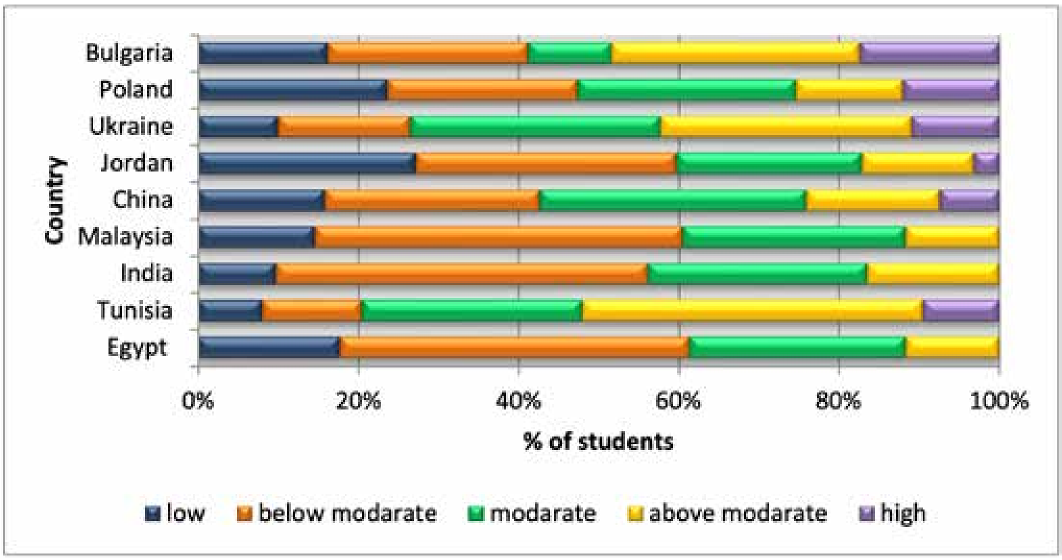

Figure 3. Distribution by levels of speed and strength training of students

students failed the test.

The representatives of Tunisia are characterized by the highest values of the indicator of speed abilities: 79.8% of the students completed the 30 m running test (Fig. 4). Students of Jordan, Malaysia and Egypt are characterized by the lowest values of the indicator of the formation of speed abilities: less than 50.0% of students completed the test.

The results of the distribution of students by levels of dexterity development are shown in figure 5.

As can be seen from figure 5, students of China and Tunisia have the highest indicators of the level of dexterity development - 78.7% and 73.8%, respectively. The lowest indicators are among students from Jordan and Egypt – 45.9% and 35.7%, respectively. It should be noted that the overall level of dexterity preparedness of students was relatively higher than speed, speed-strength preparedness and cardiorespiratory endurance.

The results of distribution according to the level of development of the stiffness of the vertebral column (flexibility) are shown in figure 6. The test results indicate significant individual fluctuations in the obtained indicators. The largest variations of the studied parameter are registered for young men of Asian countries.

Figure 6 shows that students from China and Tunisia had the highest scores - 70.7% and 68.8%, respectively, completed the test. Among students from Egypt and Jordan, there were only 38.5% and 43.9%, respectively.

The distribution of test participants according to the dynamic strength test turned out to be similar to all the previous ones (Fig. 7).

A comparison of the test results (Fig. 7) with the established norms shows that the results of this motor strength test are evaluated as following: high levels of development for representatives of China

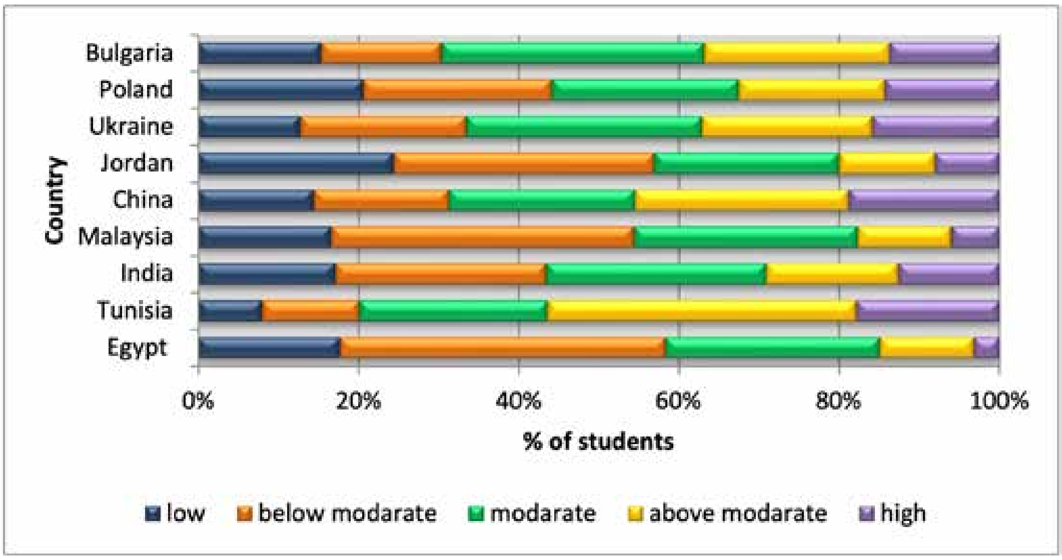

Figure 4. Distribution by levels of speed readiness of students

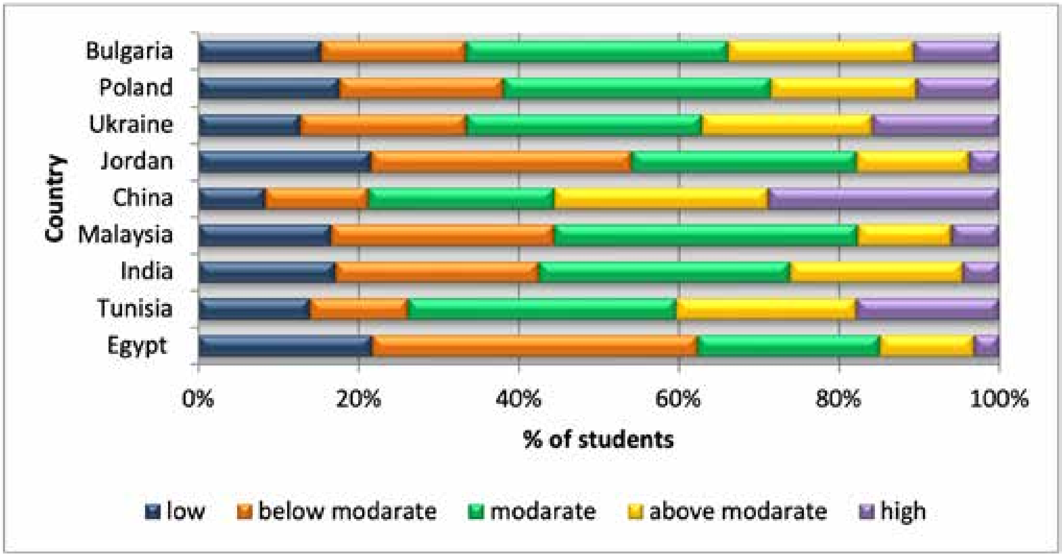

Figure 5. Distribution by levels of dexterity preparation of students

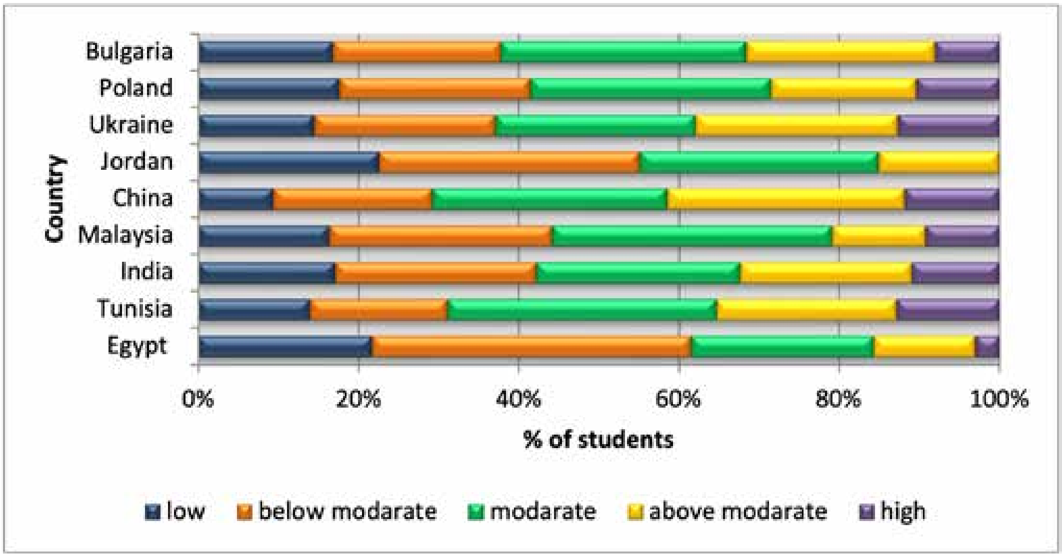

Figure 6. Distribution by levels of development of students' flexibility

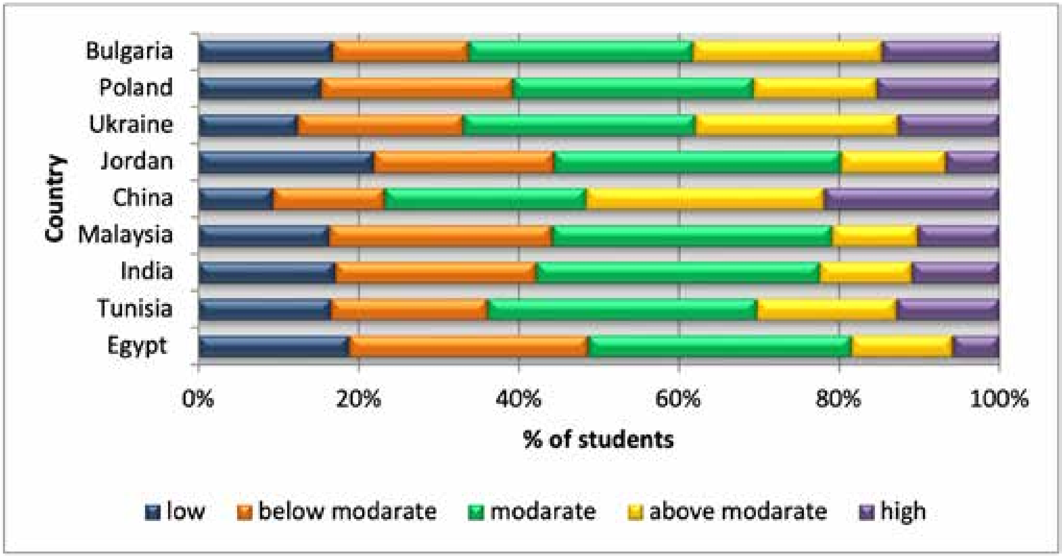

Figure 7. Distribution by levels of strength training of students

- 76.7% of students; average levels for students from European countries and Tunisia – from 63.8% to 66.9%; below the average for students in Jordan, Malaysia and Egypt – 55.6%, 55.8%, and 51.3%, respectively.

Discussion

We have established statistically significant differences in the levels of development of almost all physical abilities of students, except for cardiorespiratory endurance. It should be noted that in almost all countries (with the exception of India and Tunisia) from 41.2% to 70.0% of students are characterized by a low level of cardiorespiratory endurance development. This is in good agreement with the results of research by Gahche et al. [36]. The author announced that in 2012, in general, 42.2% of the studied contingent had a sufficient level of cardiorespiratory fitness. The authors also highlighted the lack of a statistically significant difference in the percentage of those who had an adequate level of cardiorespiratory fitness among non-Hispanic white, non-Hispanic black, and Latino youth. This is also consistent with our results. Similar data were obtained by Karimi et al. [37] and Monteiro de Almeida et al [38], who used Cooper's test in their studies. However, in the study of Monteiro de Almeida et al. [38] based on $VO_{2\ max}$ results it was found that representatives of South Asians have lower cardiorespiratory endurance than white Europeans and black Afro-Caribbeans in the UK. This ethnic difference in physical fitness is at least partially explained by ethnic differences in physical activity. However, endurance ensures versatile adaptation of internal organs, expansion of the reserves of the cardiovascular and respiratory systems, and ensures the tissue's need for oxygen. Therefore, physical (somatic, i.e. bodily) health is judged by the level of endurance development [16, 18, 37, 38, 39, 40]. The results obtained by us correlate well with data on the level of physical health of modern student youth [41].

According to our data, representatives of China and Tunisia demonstrated the highest rates of development of speed and strength abilities, where they performed the test from 69.1% to 78.8%. In studies conducted by Rouis et al. [42, 43], vertical jump height values of Afro-Caribbean participants were higher than Caucasians. This applied not only to adult men, but also had a place for preschoolers, junior high school students, and teenagers. Caia et al. [44] attributed this mainly to constitutional differences between ethnic populations, such as differences in body composition, musculotendinous properties, and muscle fiber types. The authors also emphasize that the use of vertical jump as a measure of muscle strength should be considered with caution when working with populations of different ethnic origins.

We obtained similar results when determining the level of speed formation. Thus, 79.8% of students from Tunisia complete this test. There is conflicting research regarding differences in sprinting speed by ethnicity. So, our data agreed with the results of studies by Babel et al. [45]. The authors showed that representatives of the North African region have better results in sprint running (30 m) and high jump than Europeans.

Regarding the results of flexibility testing, the highest results were demonstrated by representatives of India, China and Tunisia. Among representatives of Europe and other countries, these results were lower. These data are consistent with the results obtained by Walhain et al. [46] and De La Torre Susan [47]. It can be assumed that the differences in physical education programs in European and Asian countries are more related to sports practice. This has a significant impact on the results, as pointed out by Kemp et al. [48].

Regarding the development of dexterity, the highest results were demonstrated by representatives of China, Tunisia and Ukraine (9.04–9.14 s). Representatives of other countries demonstrated statistically lower results (9.30–10.71 s). The data are confirmed by the studies of Kuan et al. [49]. The authors compare the results between Chinese ethnic juniors and non-Chinese ethnic athletes. Analysis shows faster responses, higher accuracy, and better consistency among ethnic Chinese juniors. Our data are also consistent with the results of Lang et al. [50].

When testing strength qualities, we found that 76.7% of students from China completed the test with an average result of 13.5(2.1) times. Students from European countries showed mostly average and above average level of development of physical abilities. Students from Malaysia, Jordan, India and Egypt showed low and below average levels. Therefore, ethnicity is an important factor influencing muscle strength. However, the data obtained by us contradict the results obtained by other researchers. Thus, Woo et al. [51] showed that normal grip strength values are lower for Asian groups compared to European groups. The authors also noted that European standards should not be used as a reference standard for the Asian population. The study by Ong et al. [52] showed that subjects of Malay and Indian ethnicity had significantly lower hand dynamometry values than Chinese subjects. US and UK students had the highest mean wrist dynamometry scores. Students from Japan, Malaysia, Hong Kong, Singapore and Taiwan are ranked below. Another study reported ethnic differences in grip strength, where Aboriginal people had significantly lower grip strength compared to Malaysian Malays, Chinese and Indians [53]. Silva et al. [54] showed that dynamometry threshold values emphasize stratification by ethnicity [55]. We believe that the discrepancy in strength results between students in European countries and China can be explained by the use of different test tasks. But this approach needs a more detailed study.

According to other authors [56, 57, 58, 59], in Asian countries, physical activity is given a low priority due to the emphasis on the education of the mind, and not on the physical development of the body. Students spend most of their time studying, leaving little time for recreational activities such as physical activity. Other Asian and African countries pay little attention to physical activity due to certain traditions [60], as well as the lack of a physical training system at various levels [61]. This was also indicated in the study conducted by UNESCO [62]. Significant differences between regions regarding levels of physical activity in and out of school are shown. These levels were generally highest in European countries and lowest in the Eastern Mediterranean region. We can say that physical education program with an orientation towards increasing physical activity will most likely affect the student's motor competence. In addition, the frequency of physical education lessons per week, the content and goals of the curriculum can also be factors that affect the motor competence of young people [63].

However, when moving to a country with a different culture, the situation may change. Thus, Afable-Munsuz et al. [64] found that Chinese students from the US showed significantly higher levels of physical activity participation than those living in Hong Kong. This fact also confirms our results about the higher level of development of motor abilities of students from China and Tunisia.

Conclusions

Our results indicate the specificity of the development of motor skills of students from different countries, which is manifested in statistically significant differences in the results of test tasks. Students from different countries perform better on those tests that are closer to their known motor experience. This is due to the cultural environment, geographical factor, socio-economic status, as well as the content and goals of the physical education program.

Further work is required to determine the peculiarities of fitness state versus ethnicity as a prescription of training programmes for university male students.

Conflict of interest

The authors state that there is no conflict of interest.

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ORIGINAL ARTICLE

Pattern recognition: the effect of exercise performance modes on the effectiveness of teaching the vault to 8-year-old boys

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The study purpose was to determine the effect of exercise performance modes on the effectiveness of teaching the vault to 8-year-old boys.

Material and Methods The study participants were 32 boys aged 8 who were divided into 4 groups of 8 pesons. The children and their parents were informed about all the features of the study and gave their consent to participate in the experiment. The pedagogical experiment investigated the effect of the number of sets (x_1), the number of repetitions in a set (x_2), and a 60-second rest time on the change in the gain in the level of proficiency of 8-year-old boys in straddle vault over the buck. A method of algorithmic instructions was used in the training. The participants proceeded to the next exercise after three successful attempts.

Results Statistical analysis of the significance of the discriminant functions showed that the first function explains 81.2% of the data variation and has a high canonical correlation value ($r = 0.751$). The first function has a high discriminative ability ($\lambda = 0.332$, $p < 0.021$) and can be used to classify the modes of physical exercise performance in the process of formation of motor skills.

Conclusions The use of multivariate statistics makes it possible to determine the structure of the training program, confirm the effectiveness of the selection of motor tasks, and classify the modes of physical exercise performance during the training process. The best mode of physical exercise performance in teaching the vault to 8-year-old boys is 12 sets of 3 repetitions with a rest time of 60 seconds.

Keywords: 8-year-old boys, vault, exercise performance modes, discriminant analysis

Introduction

The problem of the formation of motor skills in school students is addressed in the papers by Litvin and Marchenko [1], Kharkovshchenko [2], Samsudin et al. [3]. The learning process lies at the heart of the physical education of school students [4, 5, 6]. The formation of fundamental motor skills in the process of physical education of school students is considered as the basis for mastering basic gymnastics exercises and sports-oriented exercises [7, 8, 9].

The importance of the selection of motor tasks, the development of programmed learning materials in the process of formation of motor skills in physical education classes is pointed ou by Kharkovshchenko [2], Kapkan et al. [10], Shueva et al. [11]. Optimizing the modes of physical exercise performance in the process of development of motor abilities [12] and formation of motor skills [13] is an important factor in increasing the effectiveness of programmed learning.

Multivariate methods of mathematical statistics, including factor and discriminant analysis, are used to investigate the regularities of the process of formation of motor skills. Factor analysis makes it possible to determine the structure and informative indicators of the motor fitness of school students [14, 15, 16]. Discriminant analysis is suitable both for determining the structure of motor fitness [17, 18, 19] and for classifying the level of fitness [20, 21, 22]. Therefore, the use of multivariate statistics will make it possible to obtain new information about the regularities of the formation of motor skills in school students.

The study purpose was to determine the effect of exercise performance modes on the effectiveness of teaching the vault to 8-year-old boys.

Materials and Methods

Participants

The study participants were 32 boys aged 8 who were divided into 4 groups of 8 pesons. The children and their parents were informed about all the features of the study and gave their consent to participate in the experiment.

Research Design

The pedagogical experiment investigated the effect of the number of sets (x_1), the number of repetitions in a set (x_2), and a 60-second rest time

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on the change in the gain in the level of proficiency of 8-year-old boys in straddle vault over the buck (Table 1).

A method of algorithmic instructions was used in the training of the elementary school-aged children. The participants proceeded to the next exercise after three successful attempts. The boys aged 8 were skilled in hurdle stepping onto springboard.

In training, the level of proficiency in motor tasks was assessed in each class using an alternative method ('performed', 'failed'), and the probability of the exercise performance was calculated (p = n/m, where n is the number of successful attempts and m is the total number of attempts).

The proficiency level was recorded for the following exercises:

1. Take-off from lying support straddle stand, and straighten up quickly.
2. 2-3 step running squat mount and straddle jump dismount.
3. 2-3 step running vault, piked straddle stand on top of side horse, and arched jump dismount.
4. From squat position on horse to straddle vault over horse or buck in front.
5. Running vault over side horse.

Statistical analysis

The study results were analyzed using the SPSS 20 statistical analysis application program. Elementary statistics were calculated. Discriminant analysis was carried out to classify the effect of the proposed modes of performance of training tasks.

The study protocol was approved by the Ethics Committee of the University. Furthermore, the children and their parents or legal guardians were fully informed about all the special aspects of the study and all the parents or legal guardians gave their consent thereto.

Results

The analysis of the study results showed that a significant difference in the level of proficiency after four modes of physical exercises is observed in the performance of exercise 5 'Running vault over side horse' ($p < 0.001$). The greatest effect is observed after the fourth mode of exercise performance. The mode of exercise performance 12 sets of 3 repetitions with a rest time of 60 seconds is the best (Table 2).

Statistical analysis of the significance of the discriminant functions showed that the first function explains 81.2% of the data variation and

Table 1. The matrix of the factorial experiment with a 2x2 factorial design in investigation of the effect of different modes of exercise repetition on the level of proficiency therein.

Experimental groups	Factors		
	x_1 number of sets (times)	x_2 number of repetitions in a set (times)	rest time (s)
1	6	1	60
2	12	1	60
3	6	3	60
4	12	3	60

Table 2. Group Statistics. Boys aged 8.

Training tasks	Training task performance modes								F	p
	1		2		3		4			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Task 1	0.4786	.32524	.5450	.30487	.7100	.27733	.7525	.15276	1.762	.178
Task 2	0.7157	.23050	.8350	.17639	.7513	.23588	.6700	.00000	1.128	.355
Task 3	0.6214	.22981	.6263	.27841	.7112	.21149	.8350	.17639	1.512	.234
Task 4	0.6643	.19060	.6263	.11575	.5450	.17254	.7525	.15276	2.341	.096
Task 5	0.6629	.00488	.5463	.24553	.5875	.15276	.9175	.15276	7.991	.001

1. – Take-off from lying support straddle stand, and straighten up quickly. 2. – 2-3 step running squat mount and straddle jump dismount. 3. – 2-3 step running vault, piked straddle stand on top of side horse, and arched jump dismount. 4. – From squat position on horse to straddle vault over horse or buck in front. 5. – Running vault over side horse.

has a high canonical correlation value (r = 0.751). The first function has a high discriminative ability (λ = 0.332, p < 0.021) and can be used to classify the modes of physical exercise performance in the process of formation of motor skills (Tables 3, 4).

The standardized coefficients of the first discriminant function show that task 5 'Running vault over side horse' has the greatest weight in the system of motor tasks, and analysis of the coefficients of the second and third functions indicates a significant contribution to the effectiveness of the target skill of the proposed tasks (Table 5).

The structure coefficients also show that task 5 'Running vault over side horse' is most correlated with the first function, the coefficients of the motor task correlation with the second and third functions indicate the integral structure of the proposed vault training program (Table 6).

The Functions at Group Centroids analysis indicates that the mode of exercise performance providing for 12 sets of 3 repetitions with a rest time of 60 seconds is the best (Table 7).

Discussion

The study assumed that the use of multivariate statistics would make it possible to determine the

Table 3. Eigenvalues. Boys aged 8.

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.292	81.2	81.2	.751
2	.237	14.9	96.1	.438
3	.062	3.9	100.0	.241

Table 4. Wilks' Lambda. Boys aged 8.

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 3	.332	28.100	15	.021
2 through 3	.761	6.951	8	.542
3	.942	1.528	3	.676

Table 5. Standardized Canonical Discriminant Function Coefficients. Boys aged 8.

Training tasks	Function		
	1	**2**	**3**
Task 1	.177	**.610**	-.121
Task 2	-.179	**.468**	**.990**
Task 3	.397	**.478**	**.655**
Task 4	.032	**-.721**	.425
Task 5	**.930**	.086	-.084

Table 6. Structure Matrix. Boys aged 8.

Training tasks	Function		
	1	**2**	**3**
Task 1	**.822***	-.243	.057
Task 2	.255	**.686***	.062
Task 3	.329	**.342***	.108
Task 4	-.269	.077	**.700***
Task 5	.357	-.559	**.585***

Table 7. Functions at Group Centroids. Boys aged 8.

Exercise performance mode	Function		
	1	**2**	**3**
1	-.295	-.660	-.259
2	-1.017	-.087	.321
3	-.466	.641	-.193
4	1.741	.023	.098

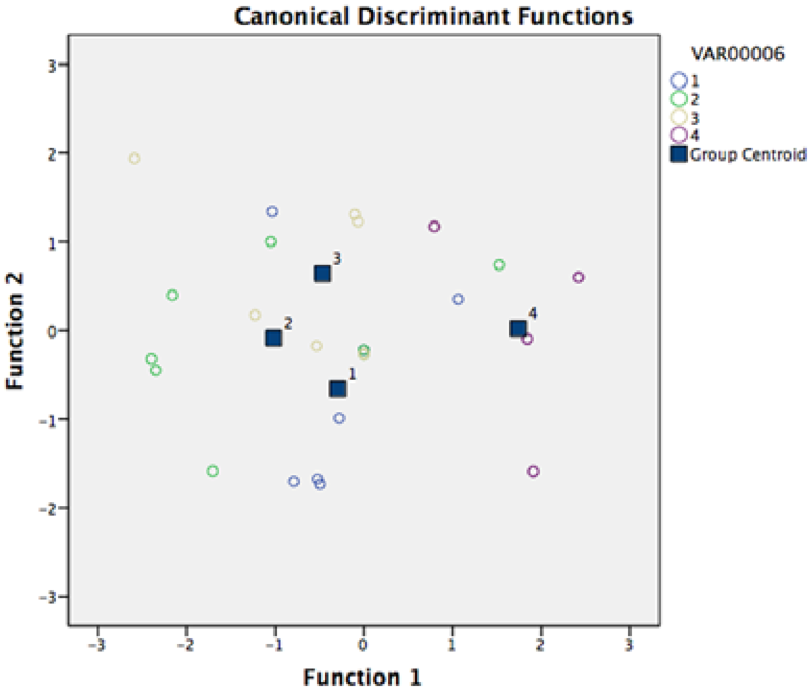

Figure 1. Canonical discriminant functions. A graphical display of the results of the classification of the modes of performance of training tasks in teaching the vault to 8-year-old boys: ■ –centroids for training task performance modes 1, 2, 3, 4.

structure of the vault training program, to confirm the effectiveness of the selection of motor tasks, and to classify the modes of physical exercise performance in the training process.

The obtained data indicate that all training tasks in the structure of the program are related to the effectiveness of the first, second and third discriminant functions. This indicates the effectiveness of their selection. Statistical analysis of the significance of the discriminant functions and analysis of centroids indicate the objectivity and reliability of the classification of physical exercise performance modes in the process of motor skills formation. The given results complement the data that discriminant analysis can be effectively used in determining the structure of motor fitness [17, 18, 19] and in fitness level classification [20, 21, 22]. This conclusion is confirmed by the provided graphic material (Fig. 1).

Discriminant analysis made it possible to establish that the selection of motor tasks, the development of training programs and the optimization of training task performance modes are all an integral process that requires further research. The obtained data complement the conclusions about the topical problems of physical education of children and adolescents [23, 24, 25] and the need to focus attention on increasing the motor activity of children [26].

The study established that the exercise performance mode providing for 12 sets of 3 repetitions with a rest time of 60 seconds is the best in the process of motor skills formation. This emphasizes that the optimization of physical exercise performance modes in the process of motor skills formation [1, 12, 21] is an important factor in increasing the effectiveness of programmed learning.

Conclusions

It was established that the selection of motor tasks, the development of training programs and the optimization of training task performance modes are all an integral process that requires further research.

The use of multivariate statistics makes it possible to determine the structure of the training program, to confirm the effectiveness of the selection of motor tasks, and to classify the modes of physical exercise performance in the training process. The exercise performance mode providing for 12 sets of 3 repetitions with a rest time of 60 seconds is the best in the process of teaching the vault to 8-year-old boys.

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