The journal represents original scientific researches of scientists from the East-European region. The Journal welcomes articles on different aspects of physical education, sports and health of students which cover scientific researches in the related fields, such as biomechanics, kinesiology, medicine, psychology, sociology, technologies of sports equipment, research in training, selection, physical efficiency, as well as health preservation and other interdisciplinary perspectives.

In general, the editors express hope that the journal “Physical Education of Students” contributes to information exchange to combine efforts of the researchers from the East-European region to solve common problems in health promotion of students, development of physical culture and sports in higher educational institutions.
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Training of students’ special endurance in ping pong sport circles

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Abstract
Purpose: to test experimentally influence of aerobic trainings (cross country training and basic aerobic) on students’ special endurance in sport oriented groups (sport circles, ping pong).

Material: 106 first year students (n=53 – control group and n=53 – experimental) participated in experiment. For determination of temporal series' trends R–S analysis was used. Prognostication of mistakes' quantity per one set was fulfilled with the help of exponential smoothing method.

Results: it was shown that exponential smoothing method permits to prognosticate by one set ahead with rather high accuracy. As initial predictor we found mean quantity of mistakes in all sets. It permits to average all internal and external factors, which influence on the next predicting indicators. Such approach increases confidence of mistakes' calculation in prognostication. Criteria of prognostication methodic for possible indicators' values were also determined.

Conclusions: the recommended time distribution in program is as follows: ping pong – 75%; cross country training and basic aerobic – 25%.

Keywords: ping pong, aerobic, special endurance, trends, fractal analysis.

Introduction
The problem of students’ physical education improvement has bee being an objects of specialists’ attention already for many years [3, 21, 23]. Analysis of literature sources shows that physical training level, psychic and moral potentials of most students is still rather low [11, 22]. It points at worsening of young generation’s physical, psychic and mental development [7, 24], progressing of motor functioning deficit [10]. All these witness about demand in seeking new ways for improvement of students’ physical, psychic and moral condition [27, 28]. Besides, it is noted that it is important to train physical qualities [4]. The supplied facts witness that students understand importance of endurance influence and its significance in preparation for labor activity. Students also understand that just this quality is the worst in most of them [4, 10]. The authors recommend approaches to correcting academic program for sport oriented groups (sport circles’ training). Improvement of students’ physical fitness has been being regarded by many scientists recent years [3, 5, 9]. Their works are devoted to physical endurance. But there is deficit of works on special endurance training in sport oriented groups (sport circles’ ping pong trainings). Besides, there are a few researches on special endurance training by cross country race means and with the help of basic aerobic in sport circles’ trainings [5, 9]. An addition to solution of the mentioned problems could be study of dynamic processes with the help of fractal geometry [17, 20, 25, 27]. The authors note that there is no universal model, which could be used for dynamic processes’ description.

The purpose of the research is to determine influence of aerobic trainings (cross country training and basic aerobic) on students’ special endurance in sport oriented groups (sport circles, ping pong).

Material and methods
Participants: 106 first year students (n=53 – control group and n=53 – experimental) participated in experiment. All participants gave written consent for participation in this experiment.

Organization of the research: the experiment was being fulfilled during academic year – from October 2015 to June 2016. Control group students were trained by program of higher educational establishments for sport oriented groups (sport circles’ trainings, ping pong). Experimental group students were trained by the worked out by us program. This program combines special sport trainings (ping pong – 75 %) and aerobic trainings (cross country training and basic aerobic – 25 %). As the base we took higher educational program for sport oriented groups (sport circles’ trainings, ping pong). Additionally, every forth training of this program included aerobic loads (cross country training and basic aerobic). Up to the middle of December experimental group students trained cross country race in the fresh air. Then the trainings were conducted in gym. With it every forth training included basic aerobic elements. At the end of March trainings again started in the fresh air, with cross country race at every forth class. At the beginning and at the end of experiment we conducted ping pong competitions. It permitted to test students’ endurance [14]. Every pair of students played five sets. The quantity of made mistakes was registered in each set.

Statistical analysis: statistical and comparative analyses of the received data were fulfilled for testing of special endurance at the beginning and at the end of experiment. The method of pair regression was used for this purpose [8]. Besides, Fisher’s F criterion and Student’s t criterion were used. Analysis of pair regression linear equation was fulfilled also [15, 17, 26]. We calculated linear coefficients of pair correlation, determination and approximation mean error [2, 6, 25]. Besides, we assessed statistical significance of regression and correlation...
parameters \([12, 13, 29]\); found excessive regression and calculated confidence intervals \([16]\).

**Results**

For prognostication it is necessary to analyze temporal series and find if the studied system is persistent or non-persistent; if its behavior is caused by determinate non-linear law or it is completely occasional. In work \([26]\) it was mentioned that any assessment method of change in time prognostication requires consideration of their temporal series’ fractal attributes. Different fractal structures in different systems cause fractal behavior of such systems’ indicators. For prognostication of such systems’ behavior (determination of changes’ tendencies) Hurst’s method is used \([13]\). In works \([16, 16]\) algorithm of Hurst’s indicator is given, which characterizes such attributes. After determination of Hurst’s indicator methodic of possible series’ values prognostication is chosen depending on its persistence. The following formula \((T – \) time) is in the base of this method:

\[
R = T^\frac{1}{2}, \quad (1)
\]

Hurst found more general equation \((1)\):

\[
\frac{R}{S} = c^n H, \quad (2)
\]

Where \(R\) – range of deviations, \(S\) – standard deviation, \(c\) – constant, \(n\) – quantity of measurements, \(H\) – Hurst’s indicator (from 0 to 1). If to take logarithm from expression \((2)\) we shall receive the following:

\[
\ln \left(\frac{R}{S}\right) = \ln(c) + H \ln(n), \quad (3)
\]

It permits to find Hurst’s indicator \((H)\) through building dependence \(\ln \left(\frac{R}{S}\right)\) on \(\ln(n)\) and determine inclination of trend line with the help of simple regression.

Algorithm of Hurst’s indicator determination (fractal method, based on \(R/S\) analysis or method of standardized range) is as follows: temporal series of length \(M\) is transformed in temporal series of length \(\frac{M-1}{n}\) by logarithmic relations \(N_t = \ln(M_t / M)\), \(t=1,2,3,\ldots,M-1\). Temporal series \(N_t\) is divided into a number of adjoining sub-periods of length \(n=2,3,\ldots,n\). Deviation for every sub-period from mean value (accumulated deviations) is calculated in the following way:

\[
X_{un} = \sum_{u=1}^{t} (e_u - M), \quad (4)
\]

Where \(n\) – length of sub-period, which changes from 2 to the length of temporal series \(t\); \(M\) – mean value of elements in sub-period; \(e_u\) – specific element of sub-period; \(u\) – number of sub-period’s element. On every iteration we calculate deviations’ range \(X_{un}\):

\[
R = \text{Max} \left( X_{un} \right) - \text{Min} \left( X_{un} \right), \quad (5)
\]

Standardizing of range we find by division on standard deviation \(S\), which is found by \(n\) values of sub-period. Then we find logarithm \(R/S\) and \(n\) and on the base of the received data build graph of linear regression. By graph of \(\ln (R/S)\) on \(\ln (n)\) function, we find inclination with method of linear approximation. Tangent of linear graph inclination angle is exactly Hurst’s indicator. Hurst’s indicator is connected with fractal dimension span of \(D\) curve by relation:

\[
D = 2 - H, \quad (6)
\]

Where \(D\) is fractal dimension span of the curve, indicator \(H\) can be from 0 to 1. For system’s analyzing Hurst’s indicator can take the following values:

1. \(0 \leq H < 0.5\) or \(1.5 < D \leq 2\) temporal series is not persistent (“pink noise”): one can observe economic system’s bent to constant change of tendency (increase is replaced by drops and vice versa). The closer its value is to zero the more changeable is series. Such systems are often called “return to average”.

2. \(H = 0.5\) or \(D = 1.5\) – numerical series is absolutely occasional (“white noise”): there is full absence of long statistic dependence (occasional behavior of economic indicator);

3. \(0.5 < H \leq 1\) or \(1<D<1.5\) – persistent temporal series (“black noise”), in which a trend is observed, as well as tendency to increasing or falling down of indicator (both in the past and in the future), The higher indicator is the more often indicator’ rising is followed by rising (falling down – by falling down).

Distinction of Hurst’s indicator from 0.5 is a particular reflection of processes’ fractal attributes, which cause temporal series. Application of persistence (or non-persistence) permits to comparatively easy and reliably prognosticate future development of the studied process on the base of his history data. In works \([2, 26]\) it was found that these attributes are valid even in case of relatively short temporal series. That is why we regard application of \(R/S\) indicator for analysis of mean quantity of mistakes in ping pong, made by experimental group students in October (see table 1). According to algorithm of Hurst’s indicator determination we construct a table for finding this indicator’s parameters. By the data of \(\ln (R/S)\) and \(\ln(n)\) temporal series \(Y\) (see table 1) we find equation of linear regression: \(Y = 0.1253x + 0.2486, R^2 = 0.8751\). Thus, standardized rage \(R/S\) – is increasing value and can be described by linear regression equation in logarithmic form:

\[
\ln(R/S)=0.1253*\ln(n)+0.2486.
\]

From this equation we find that \(H = 0.1253\) and \(D = 2-0.1253 = 1.8747\).

It means that this numerical series can be prognosticated.

In similar way we find equation of standardized range for temporal series of experimental groups (May) and control group (October and May). In table 2 there are given experimental group May data.

As per table 2 data we find the equation:

\[
\ln(R/S)=0.2314*\ln(n)+0.1526, R^2 = 0.9273. \quad H = 0.2314 \quad \text{and} \quad D = 2-0.2314 = 1.5561.
\]

Control group ping pong parameters in October are given in table 3.

By table 3 data we find the equation:

\[
\ln(R/S)=0.2138*\ln(n)+0.1653, R^2 = 0.9348. \quad H = 0.2138 \quad \text{and} \quad D = 2-0.2138 = 1.7862.
\]
Parameters of Hurst’s indicator determination in control group May ping pong are given in table 4.

By the table 4 data we find equation:

\[ \ln(R/S) = 0.2284 \times \ln(n) + 0.1483, \quad R^2 = 0.9504. \]

\[ H = 0.2284 \quad \text{and} \quad D = 2 - 0.2284 = 1.7716. \]

For temporal series (see table 1-4) Hurst’s indicator \(0 \leq H < 0.5; 1.5 < D \leq 2\) means that temporal series are non persistent (indicators’ bent to constant change of tendency).

Such type of numerical series is often called “return to average”. That is why for prognostication exponential smoothing can be chosen. This method permits to choose as initial prognostication value mean quantity of mistakes in all sets. It means that it is possible to average all internal and external factors, influencing on the next prognostication indicators. It raises confidence of errors’ calculation in prognostication. As coefficient of smoothing \((\alpha = 0.1-0.9)\) we choose the value under which mean square difference between model and actual indicators would be minimal.

For exponential smoothing we take the following formula (7):

<table>
<thead>
<tr>
<th>Set № (X)</th>
<th>Parameters for Hurst’s indicator determination (experimental group ping pong in October) 2015</th>
<th>Parameters for Hurst’s indicator determination (experimental group ping pong in May) 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity of mistakes (Y)</td>
<td>Quantity of mistakes (Y)</td>
</tr>
<tr>
<td>1</td>
<td>4.24</td>
<td>4.02</td>
</tr>
<tr>
<td>2</td>
<td>5.00</td>
<td>4.45</td>
</tr>
<tr>
<td>3</td>
<td>5.90</td>
<td>4.81</td>
</tr>
<tr>
<td>4</td>
<td>6.49</td>
<td>5.04</td>
</tr>
<tr>
<td>5</td>
<td>7.09</td>
<td>5.19</td>
</tr>
</tbody>
</table>

Statistical indicators for R/S analysis

Length of sub-period n

<table>
<thead>
<tr>
<th>Mean value</th>
<th>Max</th>
<th>Min</th>
<th>R=Max-Min</th>
<th>S</th>
<th>R/S</th>
<th>Ln(R/S)</th>
<th>Ln(n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.165</td>
<td>0.142</td>
<td>0.129</td>
<td>0.00032</td>
<td>0.0236</td>
<td>0.03698</td>
<td>0.0709</td>
</tr>
<tr>
<td>3</td>
<td>0.00032</td>
<td>0.0236</td>
<td>0.03698</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.165</td>
<td>0.142</td>
<td>0.129</td>
<td>0.00032</td>
<td>0.0236</td>
<td>0.0370</td>
<td>0.0709</td>
</tr>
<tr>
<td>2</td>
<td>0.00032</td>
<td>0.0236</td>
<td>0.0370</td>
<td>0.0709</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.00032</td>
<td>0.0236</td>
<td>0.0370</td>
<td>0.0709</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.00032</td>
<td>0.0236</td>
<td>0.0370</td>
<td>0.0709</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Parameters for Hurst’s indicator determination (experimental group ping pong in October) 2015

Table 2. Parameters for Hurst’s indicator determination (experimental group ping pong in May) 2016

Parameters of Hurst’s indicator determination in control group May ping pong are given in table 4.
\[ F_{t+1} = \alpha A_t + (1- \alpha) F_t, (7) \]

Where \( \alpha \) is smoothing coefficient, \( A_t \) – actual value, \( F_t \) – previous prognostication value, \( F_{t+1} \) – next prognostication value. Minimal value of mean square deviations of model and actual indicators for experimental data in October 2015 is given in table 5.

Table 5 data show that for prognostication of mistakes’ quantity in sixth set (October 2015) coefficient \( \alpha \) shall be chosen as equal to 0.9 (at minimal \( \sigma \)).

Thus it is possible to prognosticate the quantity of mistakes in October:

\[ F_6 = 0.9*7.09 + (1- 0.9)*6.421 = 7.023. \]

In the same way we can prognosticate for experimental group May data and control group data in October and May (see tables 6, 7, 8).

So, prognosis of mistakes’ quantity for sixth set of experimental group in May is:

\[ F_6 = 0.8* 5.19+ (1- 0.8)*4.9772 = 5.1474. \]

So, prognosis of mistakes’ quantity for sixth set of control group in October is:

\[ F_6 = 0.9* 7.15+ (1- 0.9)*6.3495 = 7.0699. \]

Prognosis of mistakes’ quantity for sixth set of control group in May is:

\[ F_6 = 0.9* 5.79+ (1- 0.9)*5.3485 = 5.7459. \]

Mean relative error (\( \varepsilon \)), percentage of all predicted values does not exceed 10%:
Table 5. Mean square deviations of model and actual indicators in experimental group in October 2015.

<table>
<thead>
<tr>
<th>t</th>
<th>$A_t$</th>
<th>$F_{t+1}$ $\alpha=0.1$</th>
<th>$F_{t+1}$ $\alpha=0.2$</th>
<th>$F_{t+1}$ $\alpha=0.3$</th>
<th>$F_{t+1}$ $\alpha=0.4$</th>
<th>$F_{t+1}$ $\alpha=0.5$</th>
<th>$F_{t+1}$ $\alpha=0.6$</th>
<th>$F_{t+1}$ $\alpha=0.7$</th>
<th>$F_{t+1}$ $\alpha=0.8$</th>
<th>$F_{t+1}$ $\alpha=0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.24</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
<td>5.74</td>
</tr>
<tr>
<td>2</td>
<td>5.00</td>
<td>5.59</td>
<td>5.44</td>
<td>5.29</td>
<td>5.14</td>
<td>4.99</td>
<td>4.84</td>
<td>4.69</td>
<td>4.54</td>
<td>4.39</td>
</tr>
<tr>
<td>3</td>
<td>5.90</td>
<td>5.31</td>
<td>5.352</td>
<td>5.203</td>
<td>5.084</td>
<td>4.995</td>
<td>4.936</td>
<td>4.907</td>
<td>4.908</td>
<td>4.939</td>
</tr>
<tr>
<td>4</td>
<td>6.49</td>
<td>5.568</td>
<td>5.4616</td>
<td>5.4121</td>
<td>5.41</td>
<td>5.448</td>
<td>5.514</td>
<td>5.602</td>
<td>5.702</td>
<td>5.804</td>
</tr>
<tr>
<td>5</td>
<td>7.09</td>
<td>5.66</td>
<td>5.66728</td>
<td>5.73547</td>
<td>5.842</td>
<td>5.969</td>
<td>6.1</td>
<td>6.224</td>
<td>6.332</td>
<td>6.421</td>
</tr>
</tbody>
</table>

$\sigma$, mean square deviation of model and actual indicators 0.86 0.80 0.72 0.62 0.51 0.41 0.31 0.22 0.22 0.16

Table 6. Mean square deviations of model and actual indicators in experimental group in May 2016.

<table>
<thead>
<tr>
<th>t</th>
<th>$A_t$</th>
<th>$F_{t+1}$ $\alpha=0.1$</th>
<th>$F_{t+1}$ $\alpha=0.2$</th>
<th>$F_{t+1}$ $\alpha=0.3$</th>
<th>$F_{t+1}$ $\alpha=0.4$</th>
<th>$F_{t+1}$ $\alpha=0.5$</th>
<th>$F_{t+1}$ $\alpha=0.6$</th>
<th>$F_{t+1}$ $\alpha=0.7$</th>
<th>$F_{t+1}$ $\alpha=0.8$</th>
<th>$F_{t+1}$ $\alpha=0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.02</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
</tr>
</tbody>
</table>

$\sigma$, mean square deviation of model and actual indicators 0.31 0.28 0.24 0.20 0.16 0.12 0.09 0.08 0.10

Table 7. Mean square deviations of model and actual indicators in control group in October 2015.

<table>
<thead>
<tr>
<th>t</th>
<th>$A_t$</th>
<th>$F_{t+1}$ $\alpha=0.1$</th>
<th>$F_{t+1}$ $\alpha=0.2$</th>
<th>$F_{t+1}$ $\alpha=0.3$</th>
<th>$F_{t+1}$ $\alpha=0.4$</th>
<th>$F_{t+1}$ $\alpha=0.5$</th>
<th>$F_{t+1}$ $\alpha=0.6$</th>
<th>$F_{t+1}$ $\alpha=0.7$</th>
<th>$F_{t+1}$ $\alpha=0.8$</th>
<th>$F_{t+1}$ $\alpha=0.9$</th>
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<tbody>
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<td>5.74</td>
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<td>5.74</td>
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<tr>
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<td>4.548</td>
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<td>5.376</td>
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<td>5.1304</td>
<td>5.0525</td>
<td>5.0044</td>
<td>4.986</td>
<td>4.998</td>
<td>5.0389</td>
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<td>5.404</td>
<td>5.3942</td>
<td>5.4213</td>
<td>5.4758</td>
<td>5.549</td>
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<td>5.7149</td>
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<tr>
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<td>7.15</td>
<td>5.6528</td>
<td>5.651</td>
<td>5.709</td>
<td>5.8045</td>
<td>5.9206</td>
<td>6.0423</td>
<td>6.159</td>
<td>6.262</td>
<td>6.3495</td>
</tr>
</tbody>
</table>

$\sigma$, mean square deviation of model and actual indicators 0.84 0.78 0.70 0.59 0.48 0.37 0.25 0.14 0.04

Table 8. Mean square deviations of model and actual indicators in control group in May 2016.

<table>
<thead>
<tr>
<th>t</th>
<th>$A_t$</th>
<th>$F_{t+1}$ $\alpha=0.1$</th>
<th>$F_{t+1}$ $\alpha=0.2$</th>
<th>$F_{t+1}$ $\alpha=0.3$</th>
<th>$F_{t+1}$ $\alpha=0.4$</th>
<th>$F_{t+1}$ $\alpha=0.5$</th>
<th>$F_{t+1}$ $\alpha=0.6$</th>
<th>$F_{t+1}$ $\alpha=0.7$</th>
<th>$F_{t+1}$ $\alpha=0.8$</th>
<th>$F_{t+1}$ $\alpha=0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.94</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
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</tr>
<tr>
<td>5</td>
<td>5.79</td>
<td>4.846</td>
<td>4.8479</td>
<td>4.8905</td>
<td>4.959</td>
<td>5.0413</td>
<td>5.1276</td>
<td>5.2106</td>
<td>5.2852</td>
<td>5.3485</td>
</tr>
</tbody>
</table>

$\sigma$, mean square deviation of model and actual indicators 0.57 0.53 0.48 0.41 0.34 0.27 0.20 0.13 0.07
\[
\varepsilon = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{A_i - F_i}{A_i} \right| \times 100 \quad (8)
\]

Where \( n \) is quantity of sets, \( A_i \) - actual values, \( F_i \) - predicted values.

The data of experimental group comparative analysis (October 2015 and May 2016) are shown in fig. 1.

As we can see experimental group data are rather better at the end of experiment: in first set – by 0.22; in second set – by 0.55 and in the third set – by 1.09; in the forth set – by 1.02 and the fifth – by 1.9. Prognosis for sixth set in October was 7.023, and for May – 5.1474. Here we also see improvement by 1.8756.

Comparative analysis of control group data for October and May is given in fig. 2.

As we can see the data of control group also improved by the end of experiment: in the first set – by 0.31%; in the second – by 0.68%; in the third – by 0.85%; in the forth – by 1.02% and in the fifth – by 1.36%. Prognosis for sixth set in October was 7.0699, and for May – 5.74595. Here we also see improvement by 1.324.

Comparative analysis of experimental and control

---

**Fig. 1.** Comparative analysis of experimental group data of October and May ping pong sets, where \( y_o \) – data for October and \( y_m \) – data for May; 1 – 5 numbers of sets; 0 – 8.00 – quantity of made mistakes.

**Fig. 2.** Comparative analysis of control group data of October and May ping pong sets, where \( y_o \) – data for October and \( y_m \) – data for May; 1 – 5 numbers of sets; 0 – 8.00 – quantity of made mistakes.
groups data for October is shown in fig. 3.

As we see the quantity of mad mistakes at the beginning of experiment (October) is nearly equal: in the first set, in experimental group the quantity of mistakes is less by 0.01; in the second – by 0.11; in the third set the quantity of mistakes was higher by 0.11; in the forth set – by 0.07; in the fifth set it was less by 0.06. In predicted sixth set it was less by 0.0469.

Comparative analysis of experimental and control groups data for May is shown in fig. 4.

At the end of experiment (May) the quantity of made mistakes in first two sets was nearly equal: in the first set in experimental group it was higher by 0.08; in the second set – by 0.02. Starting from third set experimental group results are rather different from control group: in the third set quantity of made mistakes was less by 0.13; in the forth set – less by 0.36; in the fifth – by 0.60. In predicted sixth set it was less by 0.5985.

**Discussion**

For the first time: we proved effectiveness of methodological approach to working out of students’ physical education programs for sport oriented groups, which combines commonly accepted means of physical qualities’ training with special endurance trainings methods; we substantiated physical education program for students of sport oriented groups (sport circles trainings, ping pong), combined with aerobic exercises

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**Fig. 3.** Comparative analysis of experimental and control groups ping pong data for October, where \( e_o \) – experimental group data for October, \( c_o \) – control group data for October, \( 1 – 5 \) set numbers, \( 0 – 8.00 \) - quantity of made mistakes.

**Fig. 4.** Comparative analysis of experimental and control groups ping pong data for May, where \( e_m \) – experimental group data for May, \( c_m \) – control group data for May, \( 1 – 5 \) set numbers, \( 0 – 7.00 \) - quantity of made mistakes.
This program showed that experimental group students improved their general endurance. Though, they can lag behind in technical tactic training (sportsmanship). It is connected with the fact that every forth training loads (cross country, basic aerobic) instead of ping pong practicing. After experiment data of the fulfilled analysis witness that the chosen strategy was correct: experimental group special endurance results highly differ from those of control group (see fig. 4). Experimental group students made less quantity of mistakes; they became more attentive, concentrated and responsible in important moments of game. Our results point that aerobic loads in physical culture lessons did not influence negatively on students’ technical-tactic fitness (see fig. 1). It should be noted that at the end of experiment control group results were better in first two sets (see fig. 4) than experimental group results. It is connected with better technical tactic fitness in control group: they had more special fitness trainings. However, from the third set (in spite of less quantity of technical-tactic trainings) experimental group students demonstrate better results (see fig. 4). It results from their better special endurance.

The received results supplement the data about influence of aerobic exercises on special endurance [5, 9]. It means that with correct correlation of trainings by physical education program for students’ sport oriented groups (sport circles trainings) and at the cost of aerobic loads (cross country training and basic aerobic) it is possible to significantly improve students’ special endurance.

Acknowledgements
The present work is a component of topical scientific-research works’ plan of Kharkov state academy of physical culture “Influence of aerobic trainings on general and special endurance in sport oriented groups”.

Conclusions
It was proved that introduction of aerobic trainings (cross country race and basic aerobic elements) in training program for sport oriented groups (sport circles trainings, ping pong) positively influenced on students’ special endurance. It was shown that method of exponential smoothing permits to prognosticate one set ahead with rather high accuracy.

Conflict of interests
The authors declare that there is no conflict of interests.

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The electronic version of this article is the complete one and can be found online at: http://www.sportpedagogy.org.ua/index.php/PPS/issue/archive

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The effect of aerobic continuous training and detraining on left ventricular structure and function in male students
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2Birjand University of Medical Sciences, Birjand, Iran
3Birjand Atherosclerosis and Coronary Artery Research Center, Birjand University of Medical Science, Birjand, Iran

Abstract
Purpose: Regular exercise training induces cardiac physiological hypertrophy. The aim of this study was to determine the effect of aerobic continuous training and a detraining period on left ventricular structure and function in non-athlete healthy men.

Material: Ten untrained healthy male students (aged 18-22 years) were volunteered and participated in countryside continuous jogging programme (3days/week, at 70% of Maximum Heart Rate for 45 min, 8-weeks) and four weeks detraining afterwards. M-mode, 2-dimensional, colour and Doppler transthoracic echocardiography were performed, during resting conditions, before and after the training and after detraining period.

Results: Using t-test, we found significant difference in end systolic diameter and the posterior wall thickness, percentage shortening and ejection fraction after eight weeks training compared to before training. It was found no significant difference in end diastolic diameter, interventricular septum thickness, left atrium diameter, aortic root diameter, heart rate, systolic and diastolic blood pressures. Following four weeks detraining after training, compared with eight weeks of training was a significant difference in end diastolic diameter, percentage shortening and ejection fraction and no significant difference in end systolic diameter, posterior wall thickness, interventricular septum thickness, left atrium diameter, aortic root diameter, heart rate, systolic and diastolic blood pressures.

Conclusions: In general, eight-week aerobic continuous training and a detraining period can affect left ventricular structure and function.

Keywords: aerobic exercise, detraining, left ventricular function, echocardiography, health people.

Introduction
Physical training causes structural and functional changes in the heart, particularly in the left ventricle [14, 22, 25]. These changes constitute the cardiac adaptability phenomenon following the physiological, in contrast with the pathophysiological changes brought about by hypertension and aortic stenosis [26]. In the case of disease, the heart confronts elevated pressures, but physiologically such pressures affect the heart only during physical training. The impact of physical training on cardiac structure and function depends on type, intensity and duration of training, as well as previous physical fitness, genetics and gender [4]. Continuous, long-term physical activities exert an overload on cardiac muscles, resulting in an exogenous hypertrophic pattern with normal ventricular walls and increased ventricular (especially left ventricular) volume [7, 25]. In addition, these individuals have greater diastolic filling volume, left ventricle diameter and mass, ventricular capacity, and stronger myocardial contraction, as explained by the Frank-Starling law [6]. Studies have indicated that all cardiac morphological parameters return to pre-training values after the detraining period [9, 19].

Rodrigues et al. [21] assessed the effects of 6 months of moderate-intensity aerobic training (1 hour/day, 3 times/week) on normal hearts, 23 sedentary men aged 31.1 +/- 3.5 years. After training, there was a significantly decrease in heart rate and significantly increase in Septal and posterior wall thickness. LV diameters and ejection fraction were unchanged. Obert et al. [15] in study on 25 children (11 girls, 14 boys) were enrolled in a 2 month high-intensity aerobic training program and 25 (12 girls and 13 boys) served as controls noted significant increase in left ventricular end-diastolic diameter, whereas left ventricular wall thickness and mass were unchanged. Shortening fraction and regional systolic function were also unchanged. Tjonna et al. [24] found that aerobic interval and continuous training on average three times a week on a treadmill for 16 weeks reduced systolic and diastolic blood pressure in patients with metabolic syndrome. Ciola et al. [1] investigated the acute effects of continuous and interval aerobic exercise on 24-h ambulatory blood pressure in long-term treated hypertensive patients. They observed a decrease in mean 24-h systolic and diastolic blood pressure. Obert et al. [16] In a study on twenty-nine 10-11 year old boys and girls participated in a 13-week running program (3 x 1 h/ week, intensity: > 80% HRmax) as well as after 2 months of detraining showed that LV internal chamber dimension increased (+ 4.6 %, p < 0.01) while wall thicknesses concomitantly decreased (-10.7%, p < 0.05) after training and all cardiac morphological parameters returned to pre-training values after detraining.

Many studies have been performed on competitive athlete’s heart and most studies have investigated the effect of intense continuous training. One of the most important effects of regular physical training is the adaptation of the cardiovascular system. The basic importance of an “athlete’s heart” is manifested in two
fields: public health and competitive sport. Low intensity training is the most appropriate and the least dangerous type of physical load to maintain an optimal state of health of an individual. Considering the limitations in studying continuous training with low intensity and detraining, the present study was designed to assess its effects on the left ventricular structure and function in untrained healthy males.

Material and methods

Participants. The study was performed on ten non-athletic male students of the Azad Islamic University of Birjand (Iran) aged from 18 to 22 years (20.5 ± 1.58 years, 72.65 ± 9.19 kg, 174.2 ± 6.40 cm), took part in the study. The study protocol was approved by the research ethics committee of Payame Noor University of Tehran and was carried out in accordance with the Declaration of Helsinki. Each participant gave informed consent before enrolment. The students were not professional athletes and did not have any sports category. The criterion for cardiovascular health was the data obtained from the questionnaire devised by the researcher. Subsequently, the subjects’ ECGs were studied to confirm their cardiac health. Before the initiation to participate in the study, the subjects were informed of the process and filled out the medical sport questionnaire and the consent form.

Training programme. Training programme was designed including a 45-minutes countryside continuous jogging with 70% of the maximum heart rate (MHR), three times a week for eight weeks. The subjects warmed up for 10 min before starting the main programme, and cooled down for 10 min after the main programme. All the training sessions were supervised by the researcher. After eight weeks of training, four weeks detraining was considered.

Echocardiography. The subjects had echocardiographic examinations before and after eight weeks training and after four weeks detraining. Before echocardiography, the students’ anthropometric data were taken into consideration (height, cm; weight, kg). Ultrasonic examination was carried out before and after continuous training and detraining at rest. In the examination the wall thickness of the left ventricle and its cavity diameters were measured: left ventricular end diastolic dimension (LVEDD, mm); left ventricular end systolic dimension (LVESD, mm); percentage ejection fraction (%); percentage shortening fraction (%); interventricular septum thickness (IVST, mm); left ventricular posterior wall thickness (LVPWT, mm) left atrium diameter (LA, mm) and aortic root diameter (AO, mm). The thickness of walls was measured in the diastolic phase of the cardiac cycle.

These variables were measured at the echocardiography ward in the Birjand Vali-asr Hospital by a cardiologist. Echocardiographic examination was carried out on the unit Esaote Biomedica (Italy) with application of M-modal, two-dimensional color and Doppler transthoracic [5, 10].

The heart beat while resting was measured by 60-s count, Systolic blood pressure (SBP, mm Hg) and diastolic blood pressure (DBP, mm Hg) were measured with mercury blood pressure devices of Richter model no more than 2 times with 2–3-minute intervals on the right hand with the subject in the sitting position.

Maximum heart rate was determined by the formula:

\[ HR_{max} = 220 \, \text{beats/min} - \text{age}. \]

Statistical Analysis. Descriptive statistics, a t-test for paired data was used to assess differences between pre- and post-tests as well as detraining, and P equal to or less than 0.05 was considered as the significance level. Data normality was checked with Kolmogorov – Smirnov test.

Results

Absolute values of cardiac structural features of the subjects are summarized in Table 1. The end systolic diameter decreased and the posterior wall thickness, percentage shortening and ejection fraction increased significantly after training (P≤0.05). The end diastolic diameter, percentage shortening and ejection fraction decreased significantly after detraining (P≤0.05). The end diastolic diameter after training and the end systolic diameter after detraining did not change significantly

<table>
<thead>
<tr>
<th>Variables</th>
<th>Before training</th>
<th>After 8-weeks training</th>
<th>After 4-weeks detraining</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDD (mm)</td>
<td>48.8 ± 4.7</td>
<td>49.4 ± 3.9*</td>
<td>46.7 ± 3.9</td>
</tr>
<tr>
<td>LVESD (mm)</td>
<td>32.3 ± 2.8</td>
<td>29.2 ± 4.5**</td>
<td>31.3 ± 2.1</td>
</tr>
<tr>
<td>FS (%)</td>
<td>33.5 ± 5.1</td>
<td>40.2 ± 5.7***, v</td>
<td>32.2 ± 3.8</td>
</tr>
<tr>
<td>EF (%)</td>
<td>64.6 ± 6.7</td>
<td>70.1 ± 7.0***, v</td>
<td>60.3 ± 5.4</td>
</tr>
<tr>
<td>IVST (mm)</td>
<td>9.8 ± 1.8</td>
<td>10.12 ± 1.8</td>
<td>9.5 ± 1.9</td>
</tr>
<tr>
<td>PWT (mm)</td>
<td>7.1 ± 1.1</td>
<td>8.0 ± 1.4*</td>
<td>7.4 ± 1.0</td>
</tr>
<tr>
<td>LA (mm)</td>
<td>27.1 ± 3.6</td>
<td>27.8 ± 4.0</td>
<td>27.4 ± 4.9</td>
</tr>
<tr>
<td>AO (mm)</td>
<td>25.5 ± 2.5</td>
<td>24.9 ± 2.1</td>
<td>26.1 ± 3.6</td>
</tr>
<tr>
<td>HR (bit/min)</td>
<td>73.4 ± 9.0</td>
<td>71.2 ± 6.1</td>
<td>77 ± 9.0</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>120 ± 11.7</td>
<td>116 ± 11.7</td>
<td>115.5 ± 13.1</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>74 ± 9.6</td>
<td>71.5 ± 9.4</td>
<td>70.5 ± 11.6</td>
</tr>
</tbody>
</table>

Notes: ***, **, *: significantly different from pre-training values at p<0.001; p<0.01; p<0.05; ***, v, v: significantly different from detraining values at p<0.01; p<0.05.
(P>0.05). No significant difference was observed in the interventricular septum thickness, left atrium diameter, aortic root diameter, heart rate, systolic and diastolic blood pressures after eight week training and also after four week detraining (P>0.05).

Discussion

In the present study, following eight weeks continuous training the left ventricular end diastolic diameter increased no significantly and the end systolic diameter decreased significantly. Rodrigues et al. [21], Park et al. [18] reported no significantly change in the end diastolic diameter and end systolic diameter after aerobic exercise. Conraads et al. [2] showed a decrease in left ventricular end-systolic diameter in the trained heart failure group. Aerobic activities bring about a volume overload which increases the initial diastolic filling at rest and exercise. Decrease of left ventricular systolic diameter after aerobic training may indicate a decrease in residual blood volume in the left ventricle. This implies a better emptying of the ventricle with each systole and as a result of exercise with volume overload on left ventricle [17]. After four weeks of detraining the left ventricular end diastolic diameter decreased significantly and the end systolic diameter had no significant increase. Changes in left ventricular dimensions after detraining shows that, the effects of training on left ventricle returned to that of before training.

Percentage shortening fraction (FS %) and percentage ejection fraction (EF %) increased significantly after training. D’Andrea et al. [3] observed a significant increase in percentage shortening fraction. Haykowsky et al. [8] observed a significant increase in percentage ejection fraction. On the other hand, Park et al. [18] did not observe significant differences in percentage shortening fraction and percentage ejection fraction after aerobic exercise. The significant increase in myocardial contractility could be due to the decreased left ventricular end systolic diameter after training and as a response to the increase in the stroke volume. Thus, increase in the percentage the shortening fraction of the left ventricular muscle fibres showed indicated an increase in the volume of blood pumped by the left ventricle at each of the left ventricular contraction. These results show increased percentage ejection fraction after eight weeks of training and indicates the superiority of left ventricular function after exercise. There was a significant decrease after four weeks detraining in FS% and EF%.

During endurance training, heart needs to adapt to both volume and pressure load. The heart responds by increasing left ventricular internal diameter and left ventricular wall thickness. Hence the heart responds predominantly with eccentric hypertrophy [11, 13]. After 8 weeks of training, there was no significant increase in interventricular septum thickness and significant increase in posterior wall thickness. Rodrigues et al. [21] reported a significant increase in Septal and posterior wall thickness after aerobic training. Obert et al. [15] noted that the left ventricular wall thickness and mass were unchanged after aerobic training. Increase in diameter of posterior wall and interventricular septum thickness is probably due to an increase in the left ventricular mass index, which can be regarded as an adverse precursor of left ventricular hypertrophy. After detraining interventricular septum thickness and posterior wall thickness decreased no significantly.

After eight weeks training the left atrium diameter (LA) showed no significant change. Also after detraining not observed significant change in LA. The aortic root diameter (AO), after eight weeks training decreased no significantly and after detraining increased no significantly. Several studies have shown that structural and functional changes in the left ventricle during exercise are higher greater than in other parts of the heart [14, 20, 26]. Therefore, the training performed in this study was not effect on LA and AO.

After eight weeks training the resting heart rate (HR) decreased and after four weeks detraining increased no significantly. Meyer et al. [12] observed increase in the heart rate after training. On the other hand, Rodrigues et al. [21] showed decrease in heart rate after aerobic training. Systolic and diastolic blood pressure after training and detraining decreased no significantly. Tjonna et al. [24] Ciocac et al. [1] noted a decrease in systolic and diastolic blood pressure after training. Park et al. [18] founded significantly decrease in systolic blood pressure after aerobic exercise and Shiotani et al. [23] noted a significant decrease in heart rate and no significant changes in blood pressure. In training and competition, endurance-trained athletes sustain long intervals with high cardiac output, high heart rate, high stroke volume and a moderate increase in mean arterial blood pressure. Dynamic exercise imposes a volume load on the left ventricle. The cardiac output of trained endurance athletes may increase from 5 to 6 l/min at rest to up to 40 l/min during maximal exercise. Besides an increase in cardiac output, the blood pressure increases as well, although not to the same extent as during strength training [13]. Lack of change in heart rate, systolic and diastolic blood pressure variables in this study may be due to insufficiently long training and non-athletic subjects. Overall, these contradictory results are probably due to differences in training duration, subjects, experience, ethnicity, and gender. To obtain greater effectiveness, it may be recommended that researchers choose subjects with more available time (full time subjects) and conduct the study on a longer period of time.

Conclusions

In conclusion, increase in diastolic diameter and decrease in systolic diameter shows a volume overload on left ventricle and an enlargement of LV internal chamber dimension and an increase in wall thickness. Thus changes in the thickness of the septum and posterior wall represent the heart adaptations to an excessive stress caused by training program application and increase in left ventricle mass. Increase in the parameters of the cardiac contractile function suggests that the continuous jogging program favors the cardiac muscle strengthening. Eight weeks
aerobic continuous jogging can cause physiological hypertrophy of left ventricle in non-athletes healthy male, systolic function of subjects improves after training and decreases after four weeks detraining. In general, this training program can appropriate and effective training method to improve cardiovascular function, particularly left ventricular function in healthy people.

Conflict of interests
The authors declare that there is no conflict of interests.

References

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Fitness callanetics in physical education of girl students

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Abstract

**Purpose:** to study callanetics as modern direction in girl students' physical education.

**Material:** in the research 1st year girl students of age 16-17 years (n=35) participated. The girls were trained in Callanetics sport circle twice a week in free time. Every training lasted 60 minutes. The program was designed for 72 hours and contained: theoretical part, practical part, control part, tasks for independent work and eating recommendations.

**Results:** motives for girl students' practicing callanetics were found. We registered positive changes in anthropometric indicators, power abilities and flexibility. After two months' training body mass of girl students reduced. We showed need in changing physical culture trainings' forms and methods in universities. It is offered to actively use static-dynamic exercises.

**Conclusions:** when fulfilling callanetics exercises one should strictly follow a number of methodic techniques, which will increase trainings' effectiveness and make them health related.

**Keywords:** girl students, callanetics, motivation, mass, body, power abilities, flexibility.

Introduction

Starting adult life by first year students is an important step, requiring mobilization of young organism's all systems and organs. First year of study in higher educational establishment is usually connected with student's adaptation to new life conditions and life positions' formation in student's personality. In this period, physical culture teacher plays especial role of pedagogue, orator and animator in one person. It permits to stimulate student for formation valuable attitude to personal motor functioning, to cultivate demand in regular physical culture practicing.

Seeking of new of physical education innovative technologies, which would be of health related character and meet youth's requirements are important problem for teachers [10, 11, 14, 18]. Physical culture classes shall motivate students for systemic physical exercises' practicing. A number of scientific works is devoted to new approaches to students' physical education. The authors note that at physical culture classes more attention shall be paid to cultivation students' personal components of healthy life style [16, 17, 25]. Besides, scientists found that both: traditional physical culture lessons and specialized ones approximately equally influence on formation of healthy life style personal components in students.

To fight successfully with students low physical condition and poor health authors recommend to use HOT IRON exercises, which positively influence on girls and boys' power and endurance [25]. Besides, positive influence of health related trainings, based on aqua-aerobic, on students' physical workability is noted [28]. Chinese health related gymnastic Wushu, practiced barefoot and under musical accompaniment, improves students’ self feeling and increases their psychic and physical workability [23]. That is why it would be purposeful to use fitness Yoga programs for girl students [30].

In recreational and health related spheres of students’ physical education special place is taken by callanetics and Pilates. Pilates positive influence on cardio-respiratory indicators of healthy students is mentioned in many works [21, 24]. The authors note that after 10 weeks’ course indicators of heart beats rate improved (135.4–124.2 bpm) as well as breathing coefficient (1.1–0.9). Pilates practicing weakens stress, anxiety, fatigue and improves students’ self-feeling and motivation [15, 21, 26, 27].

Theoretical principles of motivation’s formation for callanetics practicing by students are regarded in other works [5, 8]. Their authors note that insignificant intensity and easiness of callanetics exercises permit to recommend them for application at physical education trainings of students with posture disorders [4, 10, 11].

Analysis of literature sources showed that fitness directions have become an important reserve of physical culture health related-recreational system for students.

In connection with the above mentioned it seems to be relevant to work out author program "Callanetics" and implement it in girl students’ physical education.

**Hypothesis:** it is assumed that for successful strengthening of students’ physical condition, physical fitness and health it is necessary to change physical culture forms and methods in universities. It is offered to actively apply static-dynamic exercises – CALLANETICS. This system implies fulfillment of exercises without objects, with dumbbells and balls. It facilitates development of girl students’ flexibility, strength and power endurance.

**The purpose of the work** is to study callanetics as modern direction in girl students’ physical education.

**Material and methods**

**Participants:** in the research 1st year girl students of age 16-17 years (n=35) participated. By results of medical examination all girl students were related to main health group (having no health problems) and preparatory health group (with insignificant health problems).

**Organization of the research:** in the research 1st year girl students of age 16-17 years (n=35) participated.
Before the researches we analyzed students’ medical records for recent five years. Than we questioned first year students to find their interests and motives for systemic motor functioning practicing.

Main research was fulfilled in October-November 2016-2017 academic year. Girl students attended Callanetics sport circle twice a week in free time. Every training took 60 minutes and consisted of warming up, main part and final part (with breathing and relaxation exercises).

As the base of callanetics program we used psychological-pedagogic pre-conditions of formation of motivation for physical culture practicing [7]. The program includes targeted, functional and resulting blocks.

Targeted block is a spectrum of targets and tasks to be realized in formation of motivation for callanetics practicing. The main tasks of this block are:

1. Determination of girl students’ health by medical examination;
2. Finding of motives and reasons influencing on practicing different kinds of physical activity;
3. Stage-by-stage control of power abilities, flexibility and functional indicators’ level.

Functional block components:

1. Training: training of exercises and development of physical qualities. It implies: formation of knowledge about callanetics as a mean of student’s physical education and personal physical culture as well as working out of program-methodic complex for callanetics training.
2. Cognitive – includes formation of students’ knowledge about callanetic exercises’ application in physical education, independent trainings, optimization and increase of own organism’s functional potentials in learning and working life activity.
3. Axiological – means formation students’ ideas about physical culture and callanetics as means of health protection and improvement, rational eating and avoiding harmful habits. Such understanding shall become an integral part of healthy life style.
4. Motivational component includes formation of firm interest and desire to practice callanetics as means of physical form, good self feeling and mood sustaining.

Resulting block implies receiving data of all blocks. Further analysis of these data will permit to conclude about effectiveness of the worked out and implemented in practice complex “Callanetics”.

In our research we registered girl students’ weight-height indicators, results of strength and flexibility testing. Strength was tested with the following exercises: 1) “incomplete torso rising” from lying on back position, arms are stretched along torso, hands touch starting mark. Girl student raises head and shoulders with lower edge of shoulder blades being immobile. The quantity of risings is registered. 2) “Lying on forearms” Initial position (I.p.) is lying on forearms, with feet parted on width of hip joints. Girl student takes position of “plank” with the back of the head, shoulders, shoulder blades and buttocks being on one line. No arching in lumbar spine is admitted. The time of keeping such position is registered. 3) “Pressing ups in lying position”, quantity of times. For backbone flexibility traditional test was used: ‘forward bending. I.p. was sitting position with legs parted.

Statistical analysis: was fulfilled with the help of Excel program. We calculated mean arithmetic (Xav); error of mean arithmetic (m), variation coefficient (V). Differences between mean values were assessed with Student’s t-test.

Results

On initial stage of our research we fulfilled analysis of girl students’ health fir recent five years. We analyzed medical records of 1349 first year girl students. Medical personnel of the university traditionally distribute students into health groups: main, preparatory and special. Separately there exists group of therapeutic physical culture for students with in-born health problems.

As we can see in fig., the quantity of healthy students is reducing. For example for recent five academic years percentage of main group students decreased from 88.62% (at the beginning of 2011-2012 ac. yr.) to 68.7% (in 2015-2016 ac. yr.). Percentage of students with light health problems (preparatory health group) changed in heterochronic way. At the same time percentage of special health group students increased more than two times (from 6.4% to 15.1%).

Fig.1. Students’ distribution into health groups for recent five academic years 2011-2016

A – main group; B – preparatory group; C – special group; D – group of therapeutic physical culture (TPC); HG – health groups.
At the beginning of 2011-2012 academic year there were registered single cases (0.6%), when, by results of medical examination, students, in connection with heavy diseases, were oriented on therapeutic physical culture. During period of study the quantity of such students increased several times (up to 3.2%). Especially troublesome is the fact that, by different reasons, students often disguise their actual health state.

First year of study requires formation of contact between teacher and student, cultivation of healthy life style skills in students, application of innovative technologies in physical education sphere.

Then we carried out questioning for understanding motives for active practicing of physical culture (callanetics in particular). As the main motives, students called: wish to have handsome constitution”, “receive positive emotions through movements”, “to be healthy”, “it is in fashion to watch oneself”.

On the base of questioning results and medical records’ analysis we worked out program-methodic complex “Callanetics” for first year students. The program is designed for 72 hours and includes theoretical, practical and control parts as well as tasks for independent work and eating recommendations.

Callanetics is slow, quiet gymnastic with static loads. Such trainings facilitate strengthening of muscles and reduction of body mass and volume. The trainings are of traditional structure: preparatory part, main part and finalizing part. Duration of training is 60 minutes.

When training, it is necessary to observe some methodic techniques:

1. Callanetics is a gymnastic of uncomfortable positions and requires constant concentration of attention in every exercise;
2. Loads’ intensity and duration shall be increased gradually. Load increment shall be 3-5% every week. At initial stage, minimal time for every posture shall be 30 sec. and be increased gradually up to 100 sec.;
3. Static-dynamic character of movements implies fulfillment of exercises in static regime of muscles' work. If movement is necessary, it shall be smooth. Sharp movements are not recommended. Traveling shall not be more than 1-2 cm;
4. Main part shall ensure variability of exercises. Traditional complex of callanetics system consists of 30 exercises of different orientation: exercises for muscles’ warming up (6); exercises for abdomen muscles’ strengthening (4), for legs (6), for thighs and buttocks (5); stretching exercises (6); “Belly dance” exercises (3).

Recent years, callanetics specialists have started to use exercises from Yoga and Pilates. It significantly expanded such trainings’ influence on human organism. If training consists of traditional exercises, their quantity can be 7 – 12. If instructor uses exercises from other systems, the quantity of exercises can reach 20 and more.

5. Muscular groups of all body parts shall be involved in every training;
6. Shallow, calm breathing plays important part in callanetics. In every exercise it is necessary to breathe rhythmically, but without any pauses. It is up to student to choose correlation of inhales and exhales: 1:1, 1:2 or 1:3. Power element of exercise shall be accompanied by exhale; relaxation – by inhale. At initial stage of training it is recommended to use correlation: 1 inhale to 1 exhale. With experience and fulfilling exercises for abdomen muscles it is recommended to use correlations 1:2 and 1:3.

7. Every training shall include special time for exercises for diaphragm breathing and for flat foot prophylaxis. As relaxation between exercises the following exercises for backbone relaxation are practiced: grouped rolls with different amplitude, self-massage and massage.

8. Practically all exercises, except stretching, require taking callanetics classic stance – the so-called “oppositional stretching” [2]. It shall be mastered in the first training. In fulfillment of motor task it is necessary to control correctness of this stance during all exercise.

9. Trainings shall be systematic. Only regular trainings can give maximal effect. That is why in vacation time callanetics trainings shall be practiced independently, at home.

Results of health related motor functioning practicing are realization of student’s demands and motives, which made him/her to train: improvement of self-feeling, reduction of body volume, absence of pains and so on. To ensure objectiveness of organism changes’ assessments we introduced tests in “Callanetics” complex. Assessment of physical condition is possible with control over anthropometric indicators: body length and weight. The Quetelet index is calculated by these two indicators. By results of Quetelet index body composition is assessed [9]; circumference of relaxed arm, circumference of waist, buttocks, thigh and shin. Development of physical qualities is assessed with tests for joints mobility: forward torso bending from sitting position (standing on bench); arms positioning behind back. Muscular strength is determined with the following tests: incomplete torso rising; pressing ups in lying position; keeping of “plank” posture on forearms or arms. Functional potentials of respiratory system are assessed with the following tests: vital capacity of lungs (VCL); Stanger and Genchi tests [6]. In the course of trainings students often change initial position from lying to sitting. Functional efficiency of reflex mechanisms of haemo-dynamic regulation and excitability of sympathetic innervations centers can be effectively estimated with the help of orthostatic test.

In table 1 weight-height indicators of girl students are presented as well as results of strength and flexibility testing.

Analysis of initial data shows certain body mass excess in 17 years age girl students. For the analysis we used Quetelet index for people of different age [9]. After two months’ trainings we observed increase of girls’ mean body length value and reduction of body mass in average by 1.4 kg. It facilitated reducing of body mass index.

Girl students power abilities changed positively. In exercises “Incomplete torso rising” results increased by 13.2%. It means improvement of abdomen muscles’ power endurance (power center). Indicators of exercise...
Students more and more often wish to practice modern and creative kinds of sports, forming motivation for systematic trainings. The breadth of the problem of students' health worsening is proved also by results of our studies. In opinion of a number of scientists in post-Soviet HEEs more than 50% of students have health problems [29, 30]. The authors say that such situation results from crisis state of physical education system [5, 14, 20]. The data, received by us, prove correctness of such opinions. It is connected with the fact that one academic lesson a week is quite insufficient for sustaining optimal physical form of a student.

We have worked out authors program “Callanetics” and implemented it into practice of girl students’ physical education. This kind of motor activity is popular in fitness field and can be one of variants of students’ motivating for systemic physical culture practicing [3, 5]. Results of our researches prove the opinion about usefulness of modern approaches to students’ physical education application (principle “motivation instead of compulsion”) [20, 32].

Our results prove the data about possible application of different fitness kinds in students’ teaching [28-31]. There are data about effective callanetics’ application for osteoporosis prophylaxis in second maturity women (44-55 years) [1]. Exercises’ fulfillment smoothly without sharp jerks, in static and static-dynamic modes – is characteristic peculiarity of callanetics exercises. These exercises are directed at micro contraction of surface and deep muscles. It results in quick reduction of deep fat layers [8]. Our researches prove this fact. The reason of body length change is oppositional stretching of backbone, preceding and finalizing nearly every exercise. Besides, our data and results of other research [2] witness about positive influence of callanetics exercises on students’ physical condition (reduction of body mass).

**Conclusions:**
Analysis of medical records showed progressing decrease of healthy girl students’ quantity. Alongside with it, with every year more and more girl students become member of special health groups and so, they are recommended to practice therapeutic physical culture.

Questioning results permitted to find main motives, on which girl students based, when choosing callanetics training: “desire to have handsome body constitution”, “receive positive emotions through movements”, “to be healthy”, “it is in fashion to watch oneself”.

Fulfillment of callanetics exercises requires observation of a number of methodic techniques, which make trainings effective and health related. Distinctive feature of such exercises is correct breathing and keeping working posture.

Two months’ cycle of callanetics practicing permitted to register insignificant increase of body length mean indicator and reduction of body mass. These trainings also rendered positive influence on strength and backbone flexibility of girl students.

**Conflict of interests**
The author declares that there is no conflict of interests.

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**Table 1.** Weight-height indicators of girl students and results of strength and flexibility testing

<table>
<thead>
<tr>
<th>Indicators</th>
<th>1st training</th>
<th>After 8 trainings</th>
<th>After 16 trainings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Xav</td>
<td>m</td>
<td>V</td>
</tr>
<tr>
<td>Anthropometrical indicators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body length, cm</td>
<td>166,7</td>
<td>4,69</td>
<td>2,81</td>
</tr>
<tr>
<td>Body mass, kg</td>
<td>63,73</td>
<td>6,44</td>
<td>10,1</td>
</tr>
<tr>
<td>Quetelet index</td>
<td>23,17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power abilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incomplete torso rising, times</td>
<td>24,2</td>
<td>4,88</td>
<td>20,16</td>
</tr>
<tr>
<td>Lying on forearms, sec.</td>
<td>22,13</td>
<td>5,52</td>
<td>24,9</td>
</tr>
<tr>
<td>Pressing ups in lying position, times</td>
<td>8,8</td>
<td>1,37</td>
<td>15,56</td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward torso rising from sitting position, cm</td>
<td>11,26</td>
<td>2,52</td>
<td>22,2</td>
</tr>
</tbody>
</table>

Note: mean arithmetic (Xav); error of mean arithmetic (m); variation coefficient (V)
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Study of qualified cyclists movements’ coordination structure in period of overcoming differently oriented trainings

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Abstract

Purpose: to study special aspects of pedaling structure and create diagnostic models of cyclists movements’ coordination structure under fatigue in differently oriented trainings.

Material: in the research 18 elite sportsmen participated. Sportsmen fulfilled training programs on ergo-meter, directed on development of speed-power potentials and endurance in anaerobic and aerobic work.

Results: it was found that in period of fatigue overcoming dynamic shocks in applied efforts disappear and the picture of bio-dynamic components becomes smoother. With it, relative usage of efforts’ horizontal components increases. In period of evident fatigue variability of movements’ kinematic characteristics and integrated bio-electrical activity of the tested muscles increase; cyclists’ efficiency reduces.

Conclusions: distinctions in movements’ structure of cyclists in period of fatigue overcoming witness about certain tendency to transition from impulse-type pedaling to circular type. It pre-conditioned increase importance efforts’ components and effectiveness of their usage.

Keywords: fatigue, cyclists, pedaling, electric myography.

Introduction

One of effective methodic technique of sportsmen movements’ structure perfection is training of movements’ technique in fatigue state [4, 9, 22, 30]. However, in this works there is no specifying of fatigue’s phase structure. Meanwhile, it is known that fatigue, resulted from tensed muscular work in sports, includes periods of surmountable (compensated) and not-surmountable (evident) fatigue [15, 18, 23].

The existing ideas about fatigue’s influence on sportsmen movements’ structures were formed on the base of testing repeated loads, modeling, mainly, competition functioning. With it, dynamic of fatigue’s influence on sportsmen’s movements’ coordination structure actually has not been studied. In such cases rather ambiguous is information about the following elements: degree of fatigue’s influence; character of provoked adaptation reactions; training effect of single work and series of repeated analogous loads [19, 24].

The purpose of the present work is study of pedaling structure and creation of diagnostic models of cyclists’ movements’ coordination structure under fatigue in differently oriented trainings.

Material and methods

Participants: in the research 18 elite sportsmen participated (members of cycling on track combined team of Ukraine).

Organization of the research: special aspects of cyclists’ movements’ coordination were studied in experiment, modeling differently oriented trainings. Sportsmen fulfilled training programs (on modified ergo-meter “Monark”), directed at development of speed-power potentials and endurance in anaerobic and aerobic works. Speed-power trainings were the following: 12-14 accelerations, (each lasted 15 seconds) at loads 3.0-3.5 kg with pulse within 185-210 bpm. Anaerobic trainings were the following: 6-8 series of acceleration (4 accelerations of 60 seconds duration at load 2.0-2.5 kg and pulse within 175-190 bpm. Aerobic trainings were: work with pulse at threshold of anaerobic metabolism (to be determined individually); duration 60-120 minutes and load 2.0-2.5 kg.

In our work we used complex method for biomechanical tests in laboratory experiment and in natural conditions of sport training. We studied dynamic of kinematic and dynamic characteristics of efforts’ horizontal and vertical components, applied to right pedal. Besides, we studied special aspects of thigh quadriceps and biceps, shin and frontal tibial muscle of right leg.

When analyzing electric myogram we determined: amplitude and frequency of bio-potentials, rhythm structure of absolute and relative bio-electrical activity and muscles integrated bio-electrical activity. Besides, we calculated indicators of effectiveness and efficiency of motor functioning: we determined variability of the studied movements’ characteristics. Control of pedaling velocity was fulfilled with the help of electronic leader of pedaling velocity [20].

In our complex pedagogic, bio-mechanical and biological tests we followed Ukrainian legislation on health protection, Helsinki declaration 2000, directive №86/609 of European community on people’s participation in medical-biological researches. Statistical analysis: in experimental data processing we found: mean values of indicators and their errors (X±m), difference between average values and its confidence (t, p). Besides we determined dispersion magnitude – variant around average value (σ, CV) and correlation between the tested indicators (r).

Results

Analysis of pedaling velocity dynamic showed periods of working in, “stable workability” and fatigue’s overcoming.

In the initial period of work we observed reduction of pedaling velocity, weakening of muscles’ contracting activity. Besides, we observed certain tendency to
increase of efficiency and effectiveness of efforts (see figs. 1-4). The period of working in is also characterized by significant variability and diversity of bio-mechanical characteristics’ changes, which are more expressed in trainings of anaerobic and speed-power orientation.

Then (after 28.7-35.1% of time from the beginning of work) stabilization of pedaling velocity and indicators of cyclists’ movements’ structure took place. In period of “stable workability” (its duration was from 22.6 to 33.1% from total duration of trainings) we observed little variability of kinematic (from 3.6 to 8.7%) and dynamic (from 6.8 to 13.0%) efforts’ characteristics. Besides, we noted reduction (by 6.9-8.7%) of resulting force impulse (p<0.05) and intensity of muscles’ electrical activity (p<0.05). Reduction of the tested indicators’ variability and efficiency of motor functioning are confidently expressed only in trainings, directed at speed power potentials and endurance in anaerobic work. In work of aerobic character we noted constant change of value and sign of pedaling structure’s parameters.

In final phase of training (after 57.4-62.2% of time from the beginning of work) need in sustaining of workability at pre-set level is perceived by the tested as significant difficulty. With it, (in spite of fatigue) cyclists keep the temp of pedaling still rather long time. In aerobic trainings sportsmen even increased pedaling temp to some extent.

Comparative analysis of the data in period of fatigue overcoming and in period of “stable workability” showed that integrated bio-electrical activity of the tested muscles increases (and the more work intensity is, the more increase of bio-electrical activity) (see figs. 1-4). In aerobically oriented trainings integrated bio-electrical activity of muscles in period of fatigue’s overcoming increased, comparing with period of “stable workability”, only by 2.5%. In trainings of speed-power and anaerobic character integrated bio-electrical activity of the tested muscles increased accordingly by 18.4% and by 17.7% (p<0.01).

Alongside with it, it was found that increase of resulting muscles’ contraction effect is determined by different correlation and degree of changes of quantitative

![Fig. 1](image1.png)

**Fig. 1.** Changes of pedaling velocity (%) of qualified cyclists in speed-power (a), anaerobic (b) and aerobic (c) orientation.

![Fig. 2](image2.png)

**Fig. 2.** Change of resulting force impulse (H•c) for elite cyclists’ pedaling cycle in trainings of speed power (a), anaerobic (b) and aerobic (c) orientation. A – Period of training.
and space characteristics of innervations structure of muscles’ contracting activity (see figs. 1-4).

Analysis of correlations of muscles’ bio-electrical activity characteristics permitted to mark out the factors, determining ($r$ within from 0.60 to 0.87, $p<0.01$) increase of integrated bio-electrical activity of muscles. In period of fatigue overcoming we noted increase of amplitude and reduction of bio-potentials’ frequency. Rhythm structure of bio-electrical activity in most of the tested muscles (except calf muscles) remained unchanged.

Recruiting of additional motor units is not the single mechanism of sustaining the required motor effect in conditions of muscles’ reduced contraction function. In aerobically oriented trainings (work with moderate intensity) gradation of muscular contraction strength was realized mainly at the account of motor-neurons’ activity rhythm’s change. With it, by the end of training frequency of bio-potentials’ oscillations of all muscles simultaneously increased. In comparison with period of “stable workability”, frequency of oscillations increased by 4.0-17.0% ($p<0.05$) (see figs. 1-4).

In period of fatigue’s overcoming re-distribution of activity between tested muscles takes place and internal innervations structure of movements’ changes. Changes of inter-muscular activity in period of fatigue’s overcoming are the most characteristic for work of moderate intensity. They are less expressed in speed-power oriented trainings [20].

Analysis of cyclists’ tensor-dynamic graphs (figs. 5-7) showed that by the end of training dynamic shocks in character of applied efforts disappear. The picture of bio-dynamic components becomes smoother. Independent on training’s orientation relative usage of efforts’ horizontal components increases. Impulse of vertical efforts’ force does not change significantly. These distinctions in the structure of sportsmen’s movements witness about certain tendency to transition from “impulse” type of pedaling to “circular” type. It pre-conditioned increase of importance of efforts’ useful components. As a result there was increase of their usage effectiveness in period of fatigue’s overcoming ($r=0.76$, $p<0.05$).

It should also be noted that in the process of progressing and overcome fatigue it is necessary to distinguish period of irresistible (evident) fatigue. The period of evident fatigue was observed only at trainings of speed-power and anaerobic orientation. At trainings of aerobic character pedaling velocity remained practically unchanged up to the moment of “refusal to work”. In this
Fig. 5. Changes of pedaling bio-mechanical characteristics of elite cyclists in periods of fatigue's overcoming and evident fatigue during speed-power oriented trainings.

Legend: dark column – fatigue's overcoming, light column – evident fatigue. 1 — changes of pedaling velocity in respect to pre-set value; 2 — force impulse per cycle; 3 — effectiveness of efforts. Changes of efforts’ kinematic characteristics; 4 — moment of start; 5 — moment of finish; 6 — moment of maximum; 7 — period of efforts’ application; 8 — integrated bio-electrical activity of muscles per cycle. In diagram distinctions in respect to period of “stable workability” are depicted.

Fig. 6. Changes of pedaling bio-mechanical characteristics of elite cyclists in periods of fatigue’s overcoming and evident fatigue during trainings of anaerobic orientation.

Legend: see fig. 5.

Fig. 7. Changes of bio-mechanical characteristics of elite cyclists in periods of fatigue’s overcoming and evident fatigue at trainings of aerobic orientation.

Legend: see fig. 5.
connection one of the tasks of our research was study of movements’ structure in period of evident fatigue. This period is characterized by reduction of pedaling velocity, which irreversibly reduced lower than admissible level in spite of all sportsmen’s will to keep it.

In our study we found that in period of evident fatigue bio-dynamic picture of cyclists’ efforts changes. Variability of movements’ kinematic characteristics confidently increases as well as integrated bio-electric activity of the tested muscles, while efficiency of cyclists’ work reduces (see figs. 5-7). Synchronized rhythm of motor units’ activity oftener is replaced by poly-phase bio-potentials.

Discussion
The work against the background of fatigue’s overcoming at trainings of different orientation rather positively influences on sportsmen movements’ structure. Such work naturally stimulates compensatory reactions [3]. The most characteristic is increase of muscles’ functioning tension. It expressed in involvement of additional motor units at trainings of speed-power and anaerobic orientation; in increase frequency of motor neurons’ impulses. It also expressed in activity re-distribution at level of separate muscles and muscle groups at trainings for endurance to aerobic work. In period of fatigue’s overcoming there happens “correction” of external characteristics of movements and significance of the so-called “lagging behind” elements of pedaling structure increases. In such cases it is very important to increase activity of cyclists’ resulting efforts’ usage. The mentioned by us changes in pedaling structure in period of evident fatigue witness about weakening of muscles’ contraction function and emission of discoordination in nervous centers’ functioning [11, 21, 25, 28]. In opinion of some authors [1, 6, 14, 17], increase of bio-potential oscillations’ amplitude and reduction of frequency characteristics of electric myogram (like in our researches) witness about involvement of additional motor units in active state [7, 14, 29].

The received by us data permit to assume that there are distinctions in mechanisms of muscular contractions strength gradation in period of fatigue’s overcoming, when fulfilling work of different intensity [8, 15, 32]. With it, ability to involve additional motor units under maximal loads is a substantial reserve of sustaining muscular contraction magnitude [2, 27]. When working in optimal temp, the factor of muscular activity level (in period of fatigue’s overcoming) is differentiation of motor units’ excitation rhythm [26, 31].

High level of muscular activity’s re-switching in conditions of different tiredness shall be regarded as coordination re-constructions in correlations of controlling centers. It permits to sustain resulting dynamic component of work [5, 10].

The received data can be used as diagnostic model of fatigue’s influence on cyclists’ movements’ structure in different periods of their muscular functioning. Besides, these data can be used as model of dynamic of such state progressing in differently oriented trainings. Such approach will facilitate increase of effectiveness of cyclists’ motor perfection in training process.

Conclusions
1. In period of fatigue’s overcoming dynamic shocks in character of applied efforts disappear and the picture of bio-dynamic components becomes smoother. With it relative use of efforts’ horizontal components increases, while force impulse of vertical efforts remains practically unchanged.

2. In period of evident fatigue variability of movements’ kinematic characteristics and integrated bio-electrical activity of the tested muscles increase, while efficiency of cyclists’ work reduces.

3. Distinctions in cyclists’ movements’ structure in period of fatigue’s overcoming witness about certain tendency to transition from “impulse” type of pedaling to “circular” type. It preconditioned increase of efforts’ useful components’ importance and effectiveness of their use.

Conflict of interests
The author declares that there is no conflict of interests.

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Technology of concentrated training as one of ways to optimization students’ basketball trainings

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Abstract

Purpose: to find out effectiveness of concentrated training technology in students’ basketball trainings.

Material: 55 students participated in experiment. The research was being conducted during one academic year. Skillfulness in basketball techniques was determined with the help of tests’ complex. We assessed: basketball techniques’ fulfillment and their quantitative parameters (quickness of dribbling, passes, movements and accuracy of hitting in basket). Every student was offered to fulfill 7 tests, by results of which we assessed their techniques. Every test was assessed by 12-points’ scale.

Results: We proved that for students, who did not practiced basketball trainings beforehand, it is possible to master basketball material. For saving time it was envisaged to master minimal quantity of techniques, required and sufficient for playing basketball. It was found that the technology of concentrated basketball training does not influence on students’ somatic health.

Conclusions: Criterion of the mentioned technology’s effectiveness was the level of students’ mastering of basketball techniques and their basketball playing in general. It is noted that basketball training increases effectiveness of mastering of other sport disciplines. Systemic practicing of basketball resulted in students’ success in envisaged by curriculum light athletic and gymnastic.

Keywords: training technology, basketball, game techniques, students.

Introduction

Basketball is one of effective students’ physical education means. Basketball facilitates harmonious development, complex and comprehensive influence on organism, health strengthening [11, 20, 22, 32]. Great variety of basketball movements facilitates nervous system and muscular-skeletal apparatus’s strengthening, metabolism improvement, all organism’s systems’ functioning [12, 26, 30]. However, actual students’ skills in basketball leave much to be desired. The reason of such situation is basketball’s insufficient training in school years. It is connected with the following: poor sport facilities (absence of gyms, basketball backboards, balls) in schools; imperfect methodic of physical culture classes at schools; in some schools teachers prefer training of other sport games. All these result in absence of most students’ skills in basketball. It should be noted that physical education program for higher educational establishments envisages course of basketball [8, 35].

As on to day there are many methodic recommendations and other information sources for basketball trainings. Though, mainly they are oriented on sportsmen’s training in groups of sportsmanship [12, 18, 33, 34]. Basketball specialists elucidate in their works questions of history, techniques and tactic of the game. Besides, they study methodic of sport training, organization of competitions. At the same time technology of students basketball trainings has not become a subject of separate research.

Different approaches to training have been developed for students' basketball trainings [4, 5, 8, 19]. The method of concentrated training is in their basis. Such technology stipulates mastering of minimal, but sufficient quantity of techniques for bilateral game. The technology can be realized by compact training during pre-set period [3, 10]. All these ensure for students to participate in bilateral games after the shortest possible time and satisfies students’ demand to play and compete instead of training techniques during long time. In basketball trainings authors recommend to fulfill the following procedures: determine minimal scope of basketball techniques and tactic, which would be sufficient for bilateral game; work out micro-technologies of every technique’s mastering as well as for independent mastering of every technique; work out meso-technology of tactic training and game training; determine the sequence of techniques’ training and their place in curriculum during academic year as well as their connection with other techniques and parts of curriculum; ensure the correspondence of academic material volume to duration of training lesson; form system of control over students’ independent work [5, 6, 7, 15]. Such approaches are also used in other kinds of sports. In particular for physical loads’ optimization in Judo [14, 23, 24] and students’ physical education [17, 21, 27, 28], control of students’ motor fitness [29, 31] and schoolchildren’s [16, 17, 25]. It permits to improve students’ health and avoid excessive physical loads.

So, relevance of the present research is conditioned by basketball importance as physical education mean. It should also be added that working out of technology of students’ concentrated training requires certain substantiation.

The purpose of the research: optimization of basketball training technique in technology of students’ concentrated training.

The purpose determines the following tasks of the research:

Characterize influence of the worked out technology on students’ physical condition and physical fitness. Assess the level of students’ mastering of basketball techniques and basketball in the whole.

Material and methods

Participants: in pedagogic experiment 55 1st year students of pedagogic university participated. The
students were divided into control group (CG) (12 boys and 15 girls) and experimental group (EG) (14 boys and 14 girls). All participants were informed about aims and conditions of experiment and gave their consent.

Organization of the research: the research was being fulfilled during one academic year. At the beginning of experiment we determined groups’ homogeneity by physical fitness and physical condition indicators. Trainings in EG and CG had similar and distinctive features. Similar features: in both groups trainings were conducted in compliance with acting program, except sport games’ part. Distinctive features: CG students trained basketball in school. EG students did not train basketball in school. EG students did not train other sport games. At the end of academic year we mastered basketball techniques and their ability to play basketball in general. Besides, we determined indicators of separate techniques of one or different games. In this experiment we found no noticeable distinctions [13].

In total 72 hours were stipulated by curriculum per academic year (36 hrs – 1st semester and 36 hrs – 2nd semester). EG students trained only basketball during 20 hours in 1st semester; the rest time (16 hours) they mastered volleyball material. CG students trained volleyball during planned 10 hours, basketball (10 hours) and football (6 hours). In mastering other parts of academic program there were no distinctions [13].

In EG, during time assigned for sport games, students concentrated trained minimum of basketball techniques, which permit to ply bilateral game. In the process of experimental technology implementation in EG we followed the rule: training of one holistic game instead of separate techniques of one or different games. In this time, in CG students mastered basketball techniques and trained other sport games. At the end of academic year we assessed mastering of basketball techniques and playing basketball [5, 9]. Besides, we registered and compared indicators of both group students’ physical condition and physical fitness.

In experiment we used: physiological methods (pulse measuring for Robinson’s index and Rouffiet’ index; spirometry – for life index; dynamometry – for power index; express assessment of physical health [by G.L. Apanasenko]; pedagogic observation. Testing was used for assessment of basketball techniques’ mastering level [5]. The techniques (catching and passes of ball, dribbling, stops and throws) were assessed by 12-points’ scale. If technique was fulfilled with mistakes, from 12 we deducted points for mistakes [5]. Quickness and efficiency of basketball techniques; fulfillment were also assessed by 12-points’ scale. Physical fitness was assessed with tests for physical fitness (60 m, 1500 m, 4x9 m run; quantity of torso risings in sitting position and pressing ups in lying position; long jump; flexibility) [1].

Effectiveness of students’ concentrated basketball training technology was evaluated with the help of pedagogic experiment. Criterion of the mentioned technology’s effectiveness was level of students’ mastering of basketball techniques and their ability to play basketball in general. Besides, we determined indicators of students’ physical fitness and somatic health.

Physical fitness level was determined in both groups at the beginning of experiment. At the beginning of experiment we found no noticeable distinctions in physical fitness of EG and CG students (p>0.05).

Statistical analysis: the results of the research were processed with variation statistic methods, implying finding of mean arithmetic (M), arithmetic error (m), mean square deviation (σ) and confidence of differences by Student’s t-test (p).

Results
Application of basketball training’s experimental technology positively influenced on EG students’ physical fitness. After experiment EG boys demonstrated better results in dexterity and endurance (P<0.01). EG students’ speed-power indicators significantly improved, comparing CG students’ indicators.

Before experiment most of CG students (54%) and EG students (51%) had average level of physical fitness. Part of CG and EG students had physical fitness higher than average: accordingly 39% (girls - 57%, boys - 21,5%) and 29,5% (girls 27%, boys 33%). 15% of EG students had physical fitness level below average (girls 13%, boys 17%) and 7% of CG (girls 0%, boys 14%). Analysis of physical fitness after experiment showed that in EG quantity of students with physical fitness low level decreased (by 4%), below average (by 4%) and average (by 19%). Quantity of EG students with physical fitness above average increased by 22%; with high level – by 4%. In CG we did not register any changes in physical fitness level. In CG 14% of girls came from level above average to average level.

In some tests (shuttle run 4×9m and 1500 meters’ run) we observed substantial differences between CG and EG students after experiment. In the rest of EG indicators we observed tendency to their increment. Accordingly, percentage of students’ quantity in different groups of physical fitness also changed. It was evidence that on individual level physical fitness changed to the better.

One of criteria of experimental technology’s effectiveness assessment was its influence on students’ health. Somatic health was determined by methodic of G.A. Apanasenko. It should be noted that after concentrated basketball training technology’s realization there were found no statistically confident changes (P>0.05) in functional tests’ results in CG and EG. It permits to say that the offered technology influences on students’ health in the same way as traditional trainings methods (see table 1).

As far as the main task of experimental technology’s working out and realization was to train students to basketball one of main criteria of students’ ability to play basketball assessment was determination of their basketball techniques’ mastery.
The level of basketball techniques’ mastery was registered with the help of tests’ complex for assessment quantitative parameters of basketball techniques, fulfilled by students (quickness of dribbling, passes, movements, hitting basket). 7 tests were offered to every student. Each test was assessed by 12 points’ scale. 12 points were given by students (quickness of dribbling, passes, movements, hitting basket). 7 tests were offered to every student. Each test was assessed by 12 points’ scale. 12 points were given

Table 1. Indicators of students’ physical health before and after experiment

<table>
<thead>
<tr>
<th>Functional tests</th>
<th>Life index, ml/kg</th>
<th>Power index, %</th>
<th>Robinson’s index, conv.un.</th>
<th>Rouffiet’s index, conv.un.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Boys M±m</td>
<td>Girls M±m</td>
<td>Boys M±m</td>
<td>Girls M±m</td>
</tr>
<tr>
<td>CG</td>
<td>52 54</td>
<td>49 53</td>
<td>89 96</td>
<td>11 12</td>
</tr>
<tr>
<td>EG</td>
<td>56 50</td>
<td>55 50</td>
<td>94 90</td>
<td>10 11</td>
</tr>
<tr>
<td>t</td>
<td>1.2 1.1</td>
<td>1.6 1.4</td>
<td>1.2 1.</td>
<td>1.5 0.8</td>
</tr>
<tr>
<td>P</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

Table 2. Students’ mastery of basketball basic techniques

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Sex</th>
<th>CG</th>
<th>EG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball’s catching and passes with two hands from chest, points</td>
<td>Boys</td>
<td>8.1 ± 0.3</td>
<td>8.3 ± 0.3</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.4 ± 0.2</td>
<td>6.8 ± 0.1</td>
</tr>
<tr>
<td>One arm’s pass from shoulder, points</td>
<td>Boys</td>
<td>7.07 ± 0.26</td>
<td>8.42 ± 0.49</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.14 ± 0.33</td>
<td>8.2 ± 0.38</td>
</tr>
<tr>
<td>Dribbling, points</td>
<td>Boys</td>
<td>7.21 ± 0.38</td>
<td>8.33 ± 0.37</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.93 ± 0.5</td>
<td>8.05 ± 0.53</td>
</tr>
<tr>
<td>Stops after two steps and turns, points</td>
<td>Boys</td>
<td>6 ± 0.4</td>
<td>7.3 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>5.4 ± 0.4</td>
<td>7.7 ± 0.4</td>
</tr>
<tr>
<td>Two arms’ throw from chest, points</td>
<td>Boys</td>
<td>7.36 ± 0.34</td>
<td>7.83 ± 0.47</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.86 ± 0.33</td>
<td>8.67 ± 0.49</td>
</tr>
<tr>
<td>One arm’s throw from shoulder, points</td>
<td>Boys</td>
<td>6.29 ± 0.37</td>
<td>8.83 ± 0.41</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.07 ± 0.34</td>
<td>7.66 ± 0.37</td>
</tr>
<tr>
<td>Throw from double step, points</td>
<td>Boys</td>
<td>6.07 ± 0.41</td>
<td>8.75 ± 0.7</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>5.71 ± 0.28</td>
<td>8.87 ± 0.47</td>
</tr>
</tbody>
</table>

Notes: CG – control group, EG – experimental group.

Table 3. Quickness and efficiency of basketball techniques’ fulfillment

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Sex</th>
<th>CG</th>
<th>EG</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 accurate passes by two hands from chest to the wall at 1.5 m distance</td>
<td>Boys</td>
<td>5.2 ± 0.43</td>
<td>6.45 ± 0.68</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>4.86 ± 0.52</td>
<td>6.4 ± 0.56</td>
</tr>
<tr>
<td>20 accurate passes by one arm from shoulder to the wall at distance 2 meters</td>
<td>Boys</td>
<td>6.5 ± 0.69</td>
<td>6.6 ± 0.69</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>4.5 ± 0.79</td>
<td>6.53 ± 0.56</td>
</tr>
<tr>
<td>Left hand and right hand dribbling (2×18m)</td>
<td>Boys</td>
<td>5.14 ± 0.59</td>
<td>6.7 ± 0.82</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.29 ± 0.55</td>
<td>6.67 ± 0.63</td>
</tr>
<tr>
<td>Ball dribbling (24 m) by farther hand bypassing stands (every 6 meters)</td>
<td>Boys</td>
<td>5.92 ± 0.69</td>
<td>6.58 ± 0.64</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>4.64 ± 0.67</td>
<td>6.33 ± 0.53</td>
</tr>
<tr>
<td>20×5m moving by side step in basketball player’s stance</td>
<td>Boys</td>
<td>6.4 ± 0.6</td>
<td>6.42 ± 0.63</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>6.71 ± 0.44</td>
<td>6.6 ± 0.51</td>
</tr>
<tr>
<td>Quantity of hits in the basket from 15 attempts (5 attempts from the left, 5 from the right and 5 from the front) at distance of 1.5 meters (for girls) and 2 meters (for boys)</td>
<td>Boys</td>
<td>6.57 ± 0.5</td>
<td>8.25 ± 0.59</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>5.64 ± 0.44</td>
<td>7.53 ± 0.44</td>
</tr>
<tr>
<td>Quantity of hits in the basket from 7 attempts after dribbling by side step</td>
<td>Boys</td>
<td>4.9 ± 0.7</td>
<td>7.5 ± 0.83</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>4.21 ± 0.58</td>
<td>6.4 ± 0.77</td>
</tr>
</tbody>
</table>

80
for test’s fulfillment without mistakes. If any mistakes, some points were deducted from 12 for the mistakes.

As far as at the beginning of experiment experimental group students had no skills in basketball techniques, testing results of control and experimental groups were compared at the end of experiment.

Results of tests for students’ mastery of basketball basic techniques show the advantage of EG students, comparing with CG (see table 2). In 50% of tests EG boys demonstrated statistically confident better results than CG boys. EG girls were better than CG girls in 78.6% of tests (p<0.05). EG students also demonstrated better results in quickness and efficiency of basketball techniques’ fulfillment (see table 3).

In bilateral basketball game EG students’ actions were better than the same of CG. For assessment of students’ skill in playing basketball we used the record of observations [9]. It was found that CG students gained 5.4±0.6 points per one game, while EG students – 7.8±0.5 points (p<0.05). Results of EG and CG matches showed advantage of EG both by results of the game and by mass character of basketball techniques’ mastery. In EG all students participated in game. In CG not all students demonstrated ability to play basketball.

Between CG and EG groups 3 bilateral games were conducted, separately between girls’ teams and between boys’ teams (two times, 12 minutes each). It was found that EG boys won 2 games from 3 (with insignificant difference in scores: 34:28; 28:33; 38:32). Girls won 3 games from 3 with high difference in scores (24:6; 32:10; 42:12).

Discussion

Results of our study proved the data [8, 10, 11], that basketball practicing facilitates development and improvement of players’ physical qualities. Our researches showed that to the largest extent they influence positively on endurance, dexterity and speed-power qualities. The worked out technology did not impact noticeably on students’ somatic health. Average health index of EG and CG boys and girls corresponded to low health level that is one more prove of modern youth’s low health level.

Results of students’ functional tests proved the data of other researches [20, 22]: basketball trainings positively influence on students’ health. We also proved the fact that for assessment of students’ ability to play basketball it is purposeful to use records of observations [26, 30]. Objectiveness of assessment results by the records of observations is confirmed by results of games, carried out between the tested groups.

Scientists [2, 5, 32] note that basketball trainings improve effectiveness of mastering of other curriculum disciplines. Our results prove these data. Systemic practicing of basketball means resulted in students’ successful mastering the envisaged by curriculum material of light athletic and gymnastic.

The novelty is the data about specific aspects of students’ basketball training. We proved that it is possible to train basketball those students, who did not practice basketball beforehand. For saving time it was stipulated to master minimal quantity of techniques, required and sufficient for basketball playing. The received testing results show efficiency of the implemented technology of students’ basketball training.

Results of testing techniques’ mastery and the game itself witness that it is possible to successfully apply concentrated method of basketball trainings. It was determined that this technology permits to sustain and improve general physical qualities in the process of students’ physical education. This, experimentally tested technology of basketball training can be applied in educational establishments, which seek for optimization of educational process.

Conclusions

Implementation of concentrated basketball training technology improved physical fitness of EG students. After experiment EG boys showed better dexterity and endurance indicators (p<0.01) as well as speed-power indicators. The worked out technology did not noticeably influence on somatic health of the participants.

EG students mastered basketball techniques better than CG. EG boys demonstrated statistically confidently better results in 50% of tests. CG girls in 78.6% of tests yielded EG girls (p<0.05). Results of games between CG and EG teams show better mastery of material by EG students.

The prospects of the research: the present work does not open completely all aspects of effectiveness of students’ basketball training technology. In the future we intend to test its effectiveness and influence on students’ cognitive processes and field of vision.

Conflict of interests

The author declares that there is no conflict of interests.
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Reliability of functioning and reserves of system, controlling movements with different coordination structure of special health group girl students in physical education process

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Abstract

Purpose: to study reliability of functioning and reserves of system, controlling movements with different coordination structure of special health group girl students (low health level) in physical education process.

Material: in the research special health group girl students (n=136, age 17-19) participated. They were divided into 2 groups – control and experimental. The program, directed to increase reliability and reserves of system controlling movements, was realized. It was based on physical exercises of complicated coordination with novelty elements, which were fulfilled under musical accompaniment. The research continued one academic year.

Results: in girl students with health problems we registered higher differential thresholds, when reproducing local movements in complicated conditions. They used visual and hearing feedback channels for informing brain’s programming areas about made mistakes. They were worse teachable in training accurate movements. These girl students have less expressed compensation reserves under impact of hindering factors and interferences. It can be interpreted as non-specific crisscross negative response to motor functional system in case of health problems. All these determine reduction of reserve potentials of motor control system.

Conclusions: The main reserve potentials’ criteria of control over different coordination structure movements are: quickness of passing to program mechanism of fine movements’ regulation in stable conditions of functioning; power and effectiveness of compensatory reactions, ensuring interference immunity of system, controlling movements under interfering factors; reliability of maintaining movements’ qualitative parameters in optimal range under interfering factors; reduction of sensor interconnections in stable functioning conditions.

Keywords: girl students, health, control, fine movements, reserve potentials, physical education.

Introduction

Increase of reliability of system, controlling movements of different coordination structure, are weakly elucidated in special literature on physical education and sports [24, 26, 37, 41]. General principles of mechanisms of movements’ construction and control are reflected in a number of works [1, 5, 24, 26]. However, the problems of motor control reliability have been relatively weakly elucidated as well as reserves of system, controlling arbitrary movements in adaptation to physical loads by different age, sex and health problems people [4, 7, 15, 16].

It is known that increased physical activity is an important factor of motor system potentials’ strengthening in physical culture and sports practicing [3, 13, 14, 17]. Besides, physical activity is one of natural component of healthy life style [7, 10, 12, 30].

Reserves of movements’ control system are a component of human organism’s functional reserves (FR). However, they are relatively weakly elucidated from the following positions; mechanisms of reliability and quality of motor control [26, 28, 34, 35]; in the process healthy people’s adaptation to physical loads [4, 16, 22, 39] and students with healthy problems [9, 15, 21, 27].

Hypothesis: raising of reliability and quality of control of different coordination structure movements in students’ physical education (PE) is connected with the following: mastering of different equivalents methods of motor task’s realization; perfection of interference immunity mechanisms; increase of compensatory reconstructions’ quality in complicated conditions of functioning. Effect of complicating factors and interferences, variability of motor re-switching and fatigue are leading factors of reserve potentials of motor control system and health improvement in students in the process of PE [10, 15].

The purpose of the work is to study reliability of functioning and reserves of system, controlling movements with different coordination structure of special health group girl students (low health level) in physical education process.

Material and methods

Principles of systemic approach in biology [20], theory of motor control [1, 5, 8, 24], adaptation to physical loads [13, 14] and etc. were the methodological basis of the researches. They became theoretical base for experiment and selection of physical exercises, covering different coordination abilities, manifested in movements of different complexity.

Participants: in the research special health group girl students (n=136, age 17-19) participated. They were divided into 2 groups— control and experimental. The program, directed to increase reliability and reserves of system controlling movements, was realized. It was based on physical exercises of complicated coordination with novelty elements, which were fulfilled under musical accompaniment. The research continued one academic year.

In EG we offered additional program for coordination abilities’ development [10, 15]. Its base is physical exercises of increased coordination difficulty with novelty elements. We applied exercises of local, regional and global character with great number of motor re-switching [15, 32, 33, 40].
Difficulty of physical exercises increased at the account of changing their space, time and dynamic parameters \([10, 25]\):

1) Change of feet supporting area or its mobility in exercises for balance;
2) Functional deprivation of some sensor systems in mastering exercises for movements’ accuracy;
3) Motor skills’ combining;
4) Combinations of walk with jumps, run and catching objects;
5) Exercises’ fulfillment by signal or for limited time;

For increasing trainings’ emotional character and density we used: musical accompaniment, aerobic means; dance elements; game character of exercises.

For assessment of motor control system’s reserves we used a complex of methods of research \([19, 25, 29, 36]\). With the help of different registration methods and pedagogic control we assessed indicators, characterizing quality of motor control \([10, 31, 34, 35]\): a) skipping; b) rhythmic space hand’s movements as per the pre-set pattern (at 10 cm distance) at maximal rate; c) walking by straight line up to the pre-set benchmark (3 meters’ distance) with open and closed eyes, before and after vestibular irritation; d) tennis ball throws at mobile and stationary targets at distance of 3 meters; e) shuttle run 4×9 m – for quickness; f) reproduction of 10 cm line on paper with open and closed eyes (by pensile); g) “Flamingo” test for balance.

Girl students’ functional state was assessed by registration of cardio and respiratory functioning \([10, 31]\): heart beats rate (HBR, bpm \(^{-1}\)); breathing frequency (BF, br/min \(^{-1}\)); breathing pause in Gandhi test (Ct, sec.); maximal oxygen consumption (VO\(_{2}\)max) by calculation in test PWC\(_{170}\) \([11]\). Aerobic physical workability was determined with test PWC\(_{170}\) \([11]\).

Statistical analysis: experimental material was processed with the help of standard statistical methods, with program Statistica 12.5 \([2]\).

**Results**

Physical education during academic year resulted in positive changes in control over different coordination structure movements in both groups of girl students. At the same time, application of additional program made the studied indicators’ changes more expressed in EG (see table 1).

Before experiment EG and CG girl students did not differ by quality of motor control. After experiment EG girl students demonstrated advantage by most of the studied indicators.

In average, physical condition indicators improved by 21.1 ± 5.4% in EG and by 7.8 ± 2.1% in CG. With it,

<table>
<thead>
<tr>
<th>Groups</th>
<th>Indicators</th>
<th>Beginning of experiment</th>
<th>End of experiment</th>
<th>% of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n  X ±m</td>
<td>n  X ±m</td>
<td>p</td>
</tr>
<tr>
<td>Control</td>
<td>Deviations in final point (straight line walk – 3 meters, with closed eyes), cm</td>
<td>35 25.9 1.0</td>
<td>35 22.8 0.8</td>
<td>-12.5 p&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>Brush reproduction of 10 cm line on paper with closed eyes, (errors, mm)</td>
<td>34 8.5 0.2</td>
<td>34 8.0 0.2</td>
<td>7.4 p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Skipping, quantity/10 sec.</td>
<td>34 24.3 0.55</td>
<td>34 26.1 0.63</td>
<td>7.1 p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Skipping errors, quantity/10 sec.</td>
<td>34 0.6 0.15</td>
<td>34 0.1 0.07</td>
<td>-81.0 p=0.01</td>
</tr>
<tr>
<td></td>
<td>Shuttle run (ShR), sec.</td>
<td>35 11.2 0.07</td>
<td>35 10.9 0.11</td>
<td>-2.6 p=0.02</td>
</tr>
<tr>
<td></td>
<td>Coordination reconstruction in ShR, sec.</td>
<td>35 5.0 0.07</td>
<td>35 5.1 0.12</td>
<td>3.3 p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Flamingo test, sec.</td>
<td>77 5.9 0.1</td>
<td>69 5.7 0.1</td>
<td>3.6 p=0.05</td>
</tr>
<tr>
<td></td>
<td>Tennis ball throw for accuracy, points</td>
<td>59 1.9 0.2</td>
<td>59 2.5 0.2</td>
<td>29.6 p&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Total time of alternative both hand fingers’ touches of two circles (located at 10cm distance from each other) at maximal speed, sec.</td>
<td>77 5.7 0.1</td>
<td>77 5.9 0.1</td>
<td>3.6 P&lt;0.05</td>
</tr>
<tr>
<td>Experimental</td>
<td>Deviations in final point (straight line walk – 3 meters, with closed eyes), cm</td>
<td>35 9.0 0.2</td>
<td>35 6.2 0.22</td>
<td>44.8 p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Brush reproduction of 10 cm line on paper with closed eyes, (errors, mm)</td>
<td>35 26.0 0.9</td>
<td>35 20.1 0.7</td>
<td>-22.5 p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Skipping, quantity/10 sec.</td>
<td>54 24.4 0.42</td>
<td>54 26.7 0.35</td>
<td>9.2 p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Skipping errors, quantity/10 sec.</td>
<td>54 0.3 0.10</td>
<td>54 0.1 0.04</td>
<td>-72.2 p=0.05</td>
</tr>
<tr>
<td></td>
<td>Shuttle run (ShR), sec.</td>
<td>39 10.9 0.09</td>
<td>39 10.5 0.09</td>
<td>-3.1 p&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Coordination reconstruction in ShR, sec.</td>
<td>39 4.8 0.12</td>
<td>39 5.2 0.09</td>
<td>8.4 p&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Flamingo test, sec.</td>
<td>55 6.0 0.6</td>
<td>56 5.2 0.6</td>
<td>13.4 P=0.05</td>
</tr>
<tr>
<td></td>
<td>Tennis ball throw for accuracy, points</td>
<td>59 1.8 0.2</td>
<td>59 3.2 0.2</td>
<td>70.6 P&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Total time of alternative both hand fingers’ touches of two circles (located at 10cm distance from each other) at maximal speed, sec.</td>
<td>59 5.8 0.1</td>
<td>59 6.3 0.1</td>
<td>9.1 P&lt;0.001</td>
</tr>
</tbody>
</table>
7.5% EG girl students were moved in main health group and 3.5% - of CG girl students.

Advantage of EG girl students became noticeable by the end of experiment in fulfillment of local (space hand’s movements for accuracy and quickness), regional (straight line walk for accuracy up to the pre-set bench mark, skipping, tennis ball throws to target) and global (shuttle run) movements (see table 1). These movements have different coordination structure of control [1, 8, 36].

EG girl students improved also mastering of movements for accuracy with usage of visual feedback and in transition of program mechanism (straight line walk for accuracy, reproduction of 10 cm line on paper and etc.).

Analysis of cyclic loco-motor movements (walking with open and closed eyes before and after vestibular irritation) showed [10], that straight line walking for accuracy is realized, mainly, by hard program of regulation. Leading role of visual sensor system in training process is the most important in the stage of “afferent synthesis” [18, 20] at the beginning of training, in case of great discordance between the set program and the received results. Visual feedback channel effectively participates in correction of motor program in the stage of “afferent synthesis” – before reproduction of every exercise and in the process of its fulfillment. Hearing sensor system effectively “adjusts” motor program only in the process of its direct realization [10].

Motor perfection is accompanied by reduction of discordance errors between the formed program and results. Periodic switching off of eyesight in the process of moving increases sensitivity of proprioceptive sensor system as well as the role of visual afferentation in the following re-programming of motion. Besides, it facilitates mastering of movements for accuracy and its atomization, increasing of compensatory potentials in control system. The role of visual and hearing afferentation in correction of loco-motor moving reduces by the end of training period. With little discordance errors there happens transition to autonomous (programmed) contour of motor control with domination of proprioceptive feedback channel [10, 15]. A movement continues to be fulfilled at high quality in conditions of visual and hearing sensor systems’ functional deprivation; under effect of interferences. It is in compliance with motor control conception of N.A. Bernstein [1].

In SHG students we registered higher differential thresholds in reproduction of local movements in complicated conditions. The used worse visual and hearing feedback channels for informing brain’s programming areas about made errors. They manifested worse mastering of fine movements. Compensation reserves under impact of noises and interferences were weaker. It could be assessed as “non specific negative criss-cross effect” on motor functional system in case of health problems. All these determine reduction of reserve potentials of motor control system.

Analysis of correlations of EG girl students’ functional state and parameters of different coordination structure movements permitted to work out assessment and prognostic models (see table 2).

Analysis of the presented models showed that with improvement of organism’s functional state (by parameters of cardio functioning and external breathing) motor control quality (of fine movements) also improves. Besides, reserve potentials of motor control system strengthen, as well as reliability of main motor parameters saving under impact of interferences.

So, we found the following:

a) In EG **HBR reduction in rest state** is accompanied by improvement of coordination tests’ results by the end of experiment: in FB (r=0.598, p<0.001), in coordination reconstructions of upper limb (r=0.442, p=0.01), in throws for accuracy to stationary (r=-0.485, p<0.01) and moving

**Table 2. Regression correlation models of some indicators of functional fitness and motor coordination in EG at the end of experiment**

<table>
<thead>
<tr>
<th>Dependent indicators (y)</th>
<th>Equations of regression</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shuttle run, sec.</td>
<td>y = 8.845 + 0.025HBR</td>
<td>0.598&lt;0.001</td>
</tr>
<tr>
<td>Quantity of balance deviations in “Flamingo” test</td>
<td>y = 0.59FB-3.39</td>
<td>0.461&lt;0.01</td>
</tr>
<tr>
<td>Coordination reconstructions of upper limb, quantity.10 sec⁻¹</td>
<td>y = 7.983 – 0.027HBR</td>
<td>0.442&lt;0.01</td>
</tr>
<tr>
<td>Thrown at stationary target, points</td>
<td>y = 5.04 + 0.026GT</td>
<td>0.498&lt;0.0001</td>
</tr>
<tr>
<td>Thrown at moving target, points</td>
<td>y = 8.25 – 0.036HBR</td>
<td>-0.485&lt;0.0007</td>
</tr>
<tr>
<td>Coordination reconstruction in ShR</td>
<td>y = 9.17 – 0.071</td>
<td>-0.654&lt;0.0001</td>
</tr>
<tr>
<td>Error in 10 cm line’s reproduction with VC, cm</td>
<td>y = 1.277 + 0.021 Vr HBR 3’2p l</td>
<td>0.592&lt;0.01</td>
</tr>
<tr>
<td>Throws at stationary target for accuracy, points</td>
<td>y = 10.02 – 0.206Vr HBR 3’2p</td>
<td>-0.535&lt;0.0002</td>
</tr>
<tr>
<td>Thrown at stationary target for accuracy, points</td>
<td>y=[(0.108Vmax/MOC-0.033 HBR 3’y+1]</td>
<td>0.856&lt;0.0001</td>
</tr>
</tbody>
</table>

**Notes:** HBR – heart beats rate, bpm⁻¹; FB – frequency of breathing, br.min⁻¹; GT – Genchi test, sec. Vr HBR 3’2p l – heart beats rate in test PWC (second load), bpm⁻¹; Vr HBR 3’2r – velocity of HBR restoration during 3 minutes after load in test PWC (second load), bpm 1; VO₂max/ MOC – maximal oxygen consumption per 1 kg of body mass, ml; HBR 3’y+1 – HBR restoration during 3 minutes in test PWC (second load), bpm 1; VC – error in 10 cm line’s reproduction with visual correction (VC), cm; ShR – shuttle run, sec.
(r=-0.54, p<0.001) targets;

b) Increase of breathing pause in Ganchi test is accompanied by increase of coordination reconstructions’ quantity (r=0.498, p<0.0001);

c) HBR reduction in response to physical load in test PWC170 is accompanied by reduction of coordination reconstructions’ time in FB and vice versa (r=0.592, p<0.01);

d) Increase of HBR restoration speed after physical aerobic load (in test PWC170) is accompanied by reduction of mistakes in reproduction of hand’s local fine movements (r=-0.535, p<0.0002);

e) with increasing of VO2max per one kg of body mass and HBR reduction to 3rd minute of recreation period after load in EG we registered improvement of throws to stationary target accuracy (r=0.856, p<0.0001 – multiple regression model – see table 2.

Discussion

The conducted studies showed PH and experimental program positive influence on coordination and physical condition of girl students with weak health.

In annual pedagogic cycle general mechanisms of movements’ mastering were not changed. The experiment resulted in improvement of sensor-motor interconnections, reduction of sensor systems’ sensitivity thresholds (to perceiving of deviations from the pre-set target with fine movements in complicated conditions).

The worked out by us pedagogic program resulted also in increase of compensatory reconstructions’ effectiveness (with participation of visual and hearing afferentation).

Comparison of our results with other works [5, 8, 15, 16] that general laws of local, fine movements’ mastering and control are the same both for students with health problems and for healthy students [6]. SHG girl students differed insignificantly by mechanisms of mastering and control of local movements in stable external conditions from main health group students (having no health problems) [6, 9, 10].

Most of motor tests were fulfilled in conditions of interferences; with high requirements to accuracy and at high speed. It reflected in more expressed improvement of quality and stability of motor regulation in EG. It was an evidence of compensatory mechanisms’ effectiveness and power increase for saving motor system function’s reliability. It witnesses about increase of motor control system’s reserve potentials and is one of criteria of these reserves.

Our results showed that perfection of space fine movements’ regulation realizes in the following sequence: reduction of role of external (visual and hearing) and increase in internal (proprioceptive) regulation circuit; transition to program regulation mechanism in stable conditions of functioning. It coincides with parametrical conception of motor control in standard conditions [5].

Increase of compensatory reconstructions’ reliability under impact of interfering factors is one of criteria of motor control quality.

Domination of program regulation mechanism is observed in fulfillment of hand’s local movements and motions in stable conditions of main movement’s realization. But in conditions of interferences the role of visual and hearing feedback channels is rising for compensation of deviations and quick return to program model of movement’s realization. It coincides with conception of cyclic loco-motions’ control [1, 5].

It is characteristic that more expressed positive changes took place in movements of the highest regulation levels (C and D by Bernstein [1]): in throwing at moving target; in shuttle run; in coordination reconstruction in ShR. We also observed positive changes in exercises, regulation of which is realized at lower levels (A and B): they are more stable, more programmable; more difficult to be controlled of (walking by straight line; balance in Flamingo test; skipping). They are more resistant for interferences, more stable in reproduction and are based on steady regulation programs.

Under proper organization the worked out methodic approaches to PE provisioning permit to improve physical fitness, functional state and coordination of SHG girl students. Besides, they increase reserve potentials of their motor systems and control over movements.

The corrected PE process for girl students with health problems noticeably improved motor function, increased motor system’s reserve potentials; improved physical conditions.

Conclusions

As a result of our researches we found that the most important criteria of reserve potentials of local movements’ control system are:

- Quickness of fine movements’ mastering and transition to program mechanism of movements’ regulation in stable conditions of functioning;
- Power and effectiveness of compensatory reactions, ensuring interference immunity of movements’ control system under impact of interferences;
- Reliability of qualitative movements parameters’ saving in optimal range under impact of interference factors;
- Reduction of sensor interconnections in movements’ control system in stable functioning conditions (the principle of minimal interaction).

As on to day the following directions in solving the problem of functional reserves of movements’ control system can be promising: a) study of functional reserves of different motor control levels; b) analysis of mobilized organism’s reserves’ structures, depending on sport functioning character; c) study of switching sequence of different levels’ reserves, mechanisms of their mobilization and character of their integration in different kinds of sports; d) analysis of reserves’ trainability; e) working out of monitoring and assessment flexible systems for motor system’s reserves, differentiated by sex, age, character of health problems and other criteria.

Conflict of interests

The authors declare that there is no conflict of interests.
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Dynamic of arm’s micro movements of elite athlete
in Olympic exercises Rapid Fire Pistol and Air Pistol

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3 Ukrainian Defense Ministry of Sport Management
4 National Academy of Internal Affairs

Abstract

Purpose: to scientifically substantiate the method of contactless determination of athlete hand's movements in Olympic exercises with pistol.

Material: in the research we used the data of 37 elite athletes in exercise Air Pistol (n=32) and in exercise Rapid Fire Pistol (n=5). Registration of pistol projection’s quickness of movement in target area was realized with the help of computer system Scatt. In total we analyzed 3100 space-time parameters of athletes’ technical-tactic actions in finalizing phase of shooting cycle.

Results: we tested innovative method of contactless measuring of athlete’s hand’s micro movements in finalizing phase of shooting cycle. We found uncontrolled deviations from optimal pistol pointing position in vertical, horizontal and sagittal planes. Quickness of athlete hand’s movements in shooting process was determined.

Conclusions: we scientifically substantiated the method of contactless determination of athlete hand’s movements at a distance in Olympic exercises with pistol. Besides, we determined the dynamic of athlete’s hand micro movements in Olympic exercises Rapid Fire Pistol and Air Pistol.

Keywords: sports, shooting, pistol, method, micro movements, dynamic.

Introduction

Sport rivalry is constantly increasing on international arena, in particular at Olympic Games in exercises Rapid Fire Pistol (pistol target shooting for quickness from 25 meters distance) and Air Pistol (air pistol shooting from distance 10 meters). Accordingly demand in scientific improvement of scientific methodic provisioning of athletes’ training for official international competitions is also increasing. Due to own specific features sport shooting endures great demand in control devices with objective registration of space characteristics. Elite athletes especially need to control all complex structure of shooting technique, in order to find reserves for its elements’ improvement.

In the base of shooting technique’s improvement (for different kinds of arm) there are qualitative and quantitative changes of its micro-structure characteristics. The main reason of problems in motor technique is the fact that coaches (and athletes also) has deficiency of objective assessments of skillfulness and control over its perfection [9].

Alongside with it, the problem of registration and analysis of athlete hand’s micro movements has been studied insufficiently. In particular, uncontrolled changes of optimal position in sagittal plane have not been studied. However, statistically confident data about movements on axis Z are the necessary component, which is absent in scientific-methodic provisioning of athletes’ training. The known methods can not be applied in competition conditions, where accurate data are especially important.

So, the problem of contactless remote registration of athlete hand’s micro movements in pistol shooting process in Olympic exercises has become rather relevant.

The purpose of the work is to scientifically substantiate the method of contactless determination of athlete hand’s movements by axis X, Y and Z and micro movements dynamic in Olympic exercises Rapid Fire Pistol and Air Pistol.
Material and methods

Participants: in the research we used the data of 37 elite athletes: international masters of sports in exercise Air Pistol (n=32, including 8 member of initial staff of Combined team of Ukraine in bullet shooting); in exercise Rapid Fire Pistol (n=5, 2 of them – Champions of Olympic Games and 1 – winner and 2 – prize winners of World Cup).

Organization of the research: electronic-optical registration of pistol’s projection quickness in the area of target during shooting was realized with the help of computer system Scatt [10]. In total we analyzed 3100 space-time parameters of athletes’ technical-tactic actions in finalizing phase of shooting cycle.

Statistical analysis: the materials were statistically processed with the help of Microsoft Excel 2010 software.

In the process of the research we had to solve the following tasks:
- Testing of contactless registration model for space-time parameters of athlete hand’s micro movements by axes X, Y and Z;
- Find out the presence or absence of changes of athlete hand’s coordinated by sagittal axis Z in the process of pointing;
- Determine the dynamic of athletes-shooters hands’ micro movements in Olympic exercises Rapid Fire Pistol and Air Pistol;
- Offer the method of remote express analysis, diagnostic and correction of athlete’s pre-start readiness at official international competitions;
- Work out practical recommendations.

Results

We tested the model of contactless registration of athlete hand’s movements in the process of Olympic pistol exercises’ fulfillment. The model is called CEA16 (Contactless Electronic Analysis). Its distinctive feature is that it simultaneously registers micro movements by axes XYZ in exercises Rapid Fire Pistol and Air Pistol on the base of contactless sensors [26], (see fig. 1).

The device is characterized by high accuracy and frequency of pictures. Besides, it provides reports about discrete positions and movements. Controller uses optical sensors and infra-red light. New interactive model CEA16 permits to measure physical values in the following units: distance – millimeters; time – micro-seconds; velocity – mm/sec; angle of view – radian.

In CEA16 software internal model of human hand is used. The model prognosticates tracing, even if a part of hand is not visible. The model always ensures positions for five fingers. Tracing is optimal, when a contour of hand and fingers is clearly visible. CEA16 analyzes visible parts of hand and its internal models. The system analyzes results of previous tracings for calculation of the most probable positions of the parts, which are not visible at the given moment. Super sensitive sensors of model CEA16 movements’ controller can identify different human micro movements with preciseness 0.001 mm. CEA16 visual analyzer identifies and traces hand and fingers (see fig. 2).

With the help of CEA16 it is possible to measure micro movements of two athletes simultaneously, for express-comparison their potentials. Though we recommend keeping not more than two objects in the area of controller sensors’ action for optimal quality of micro movements’ tracing.

On the base of CEA16 model (pic. 2) we tested the method of contactless remote measurement of athlete hand’s micro movement space-time parameters in the process of Olympic exercises’ fulfillment. Earlier such data were unknown in theory and practice and not mentioned in scientific literature.

Fig. 1. Block diagram of CEA16 model for registration micro movements by XYZ axes:
1 — sportsman in start position for Rapid Fire Pistol exercise;
2 — remote sensor Leap Motion;
3 — data from remote sensor;
4 — description of athlete hand’s movement in finalizing phase of shooting;
5 — processor of identification of movement’s images;
6 — processing of identified micro movements;
7 — operational system of computer.
New model CEA16 is an aggregate of program and apparatus means, which trace movements with their further transformation in parameters of axes X, Y and Z. Model CEA16 permits to use computer in completely new way: to trace positions of athlete’s hand with speed of 200 pictures per second with the help of infra-red cameras in 3-D space.

The method implies visualization of athlete hand’s micro-movements in the process of pressing trigger. The offered name of the method of micro-movements’ measurement in the process of pressing trigger is Micro Movements of Sportsman (MMS).

1. With the help of MMS method we measured the most important space-time parameters of athlete hand’s micro movements in fulfillment of Olympic exercises Rapid Fire Pistol and Air Pistol (табл. 1).

2. Thus, we have solved the problem of contactless remote registration of athlete hand’s micro movements in the process of pistol shooting in fulfillment Olympic exercises.

3. We also found boundary values of the studied parameters for elite shooters in the process of pressing trigger. Mean value of horizontal deviations of athlete’s hand is 1.557 mm.

4. Horizontal deviations are within 1.226÷2.042 mm; mean vertical deviation of athlete’s hand from the required position was 1.941 mm; vertical oscillations of athlete’s hand in finalizing phase of pressing trigger were within 1.931÷1.990 mm.

5. Mean sagittal deviations of athlete’s hand from the required position was 3.415 mm; sagittal oscillations of athlete’s hand in finalizing phase of pressing trigger were within 3.124÷5.099 mm; mean velocity of athlete hand’s movement in finalizing phase of pressing trigger was 12.345 mm/sec.; velocity of athlete hand’s movement in finalizing phase of pressing trigger was within 11.548÷14.343 mm/sec.

On this base we affirm that in shooting Olympic exercises (Rapid Fire Pistol and Air Pistol) we statistically confidently registered micro movement in planes X, Y, Z (see fig. 3).

As a result of this fact, velocity of athlete hand’s movements in finalizing phase of pressing trigger is a variable value (see fig. 3), that conditions significant influence on efficiency of exercises’ fulfillment.

The confidence of results is proved by accuracy of computer analysis of the received data.

So, in the present work we supplied theoretical generalization and new solution of technical-tactic parameters’ express-registration in finalizing phase of pressing trigger. It permits to objectively determine an athlete’s condition and its correcting, especially in competitions. The problem has been solved with the help of MMS method. Thus, for the first time, scientific substantiation of micro movements’ computer registration has been realized for Olympic exercises Rapid Fire Pistol and Air Pistol in sagittal plane (3D) with the help of model CEA16.
Comparing with technologies of Scatt system [10] CEA16 model ensures athletes’ training by more informative interface through ordinary USB port. The system registers movements with the help of remote analysis of gestures. It is difficult to imagine the progress of scientific-methodic provisioning of elite sportsmen-shooters without CEA16 technology of gestures’ identification. Our results expand significantly the data of other studies [3, 4, 5].

The prospects of other findings in this direction imply addition of new systems to controller of model CEA16. Practical recommendations: for registration space-time parameters direct indicators of model CEA16 to exchange buffer (pressing key PrtSc) and insert it in addition (Paint, Writer, pressing key Shift+Insert). In the process of the model’s adjustment it is necessary to see device in action without touching keyboard, mouse or screen.

The next important moment is determination of the most convenient height of tracking, which is to be adjusted in options. In our testing the most convenient was standard value – 20 cm. If to work in sitting position (like in exercises of Para-Olympic sportsmen) it is necessary to reduce the height a little or use automatic tracking.

Concerning working out devices for children-junior sport schools, in model CEA16 program language Unity 3D is suitable. The model’s controller permits to control computer with the help of hands’ gestures in space. Now, interaction with computer in Windows 10 is possible, with realization of full spectrum of opportunities (complete support of multi-touch gestures).

It should be reminded that sensitivity level of CEA16 controller permits to trace even fine movements of fingers that expand its opportunities. The model itself has not big size.

Connection to computer is through USB interface. With it, accuracy of micro movements’ tracing reaches 1/100 mm. Besides, it is possible to adjust this system

### Table 1. Athlete hand’s micro movements in the process of CEA16 testing, p<0.05

<table>
<thead>
<tr>
<th>Attempts</th>
<th>Deviation by X, mm</th>
<th>Deviation by Y, mm</th>
<th>Deviation by Z, mm</th>
<th>Velocity S, mm/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.408</td>
<td>1.947</td>
<td>3.415</td>
<td>12.375</td>
</tr>
<tr>
<td>2</td>
<td>1.819</td>
<td>1.939</td>
<td>3.144</td>
<td>11.848</td>
</tr>
<tr>
<td>3</td>
<td>1.518</td>
<td>1.937</td>
<td>3.515</td>
<td>12.475</td>
</tr>
<tr>
<td>4</td>
<td>1.405</td>
<td>1.939</td>
<td>3.544</td>
<td>11.548</td>
</tr>
<tr>
<td>5</td>
<td>2.014</td>
<td>1.942</td>
<td>3.412</td>
<td>12.315</td>
</tr>
<tr>
<td>6</td>
<td>1.389</td>
<td>1.931</td>
<td>3.124</td>
<td>11.818</td>
</tr>
<tr>
<td>7</td>
<td>1.226</td>
<td>1.942</td>
<td>3.415</td>
<td>12.675</td>
</tr>
<tr>
<td>8</td>
<td>1.714</td>
<td>1.933</td>
<td>3.256</td>
<td>11.648</td>
</tr>
<tr>
<td>9</td>
<td>1.596</td>
<td>1.981</td>
<td>3.549</td>
<td>13.248</td>
</tr>
<tr>
<td>10</td>
<td>2.042</td>
<td>1.990</td>
<td>5.099</td>
<td>14.343</td>
</tr>
</tbody>
</table>

Notes: X, mm — horizontal deviations of athlete’s hand; Y, mm — vertical deviations; Z, mm — deviations in sagittal plane; S, mm/sec — velocity of athlete hand’s moving at the moment of registration.

Fig. 3. Dynamic of elite shooters hands’ micro movements in 10 series of exercise Air Pistol

Discussion
Comparing with technologies of Scatt system [10] CEA16 model ensures athletes’ training by more informative interface through ordinary USB port. The system registers movements with the help of remote analysis of gestures. It is difficult to imagine the progress of scientific-methodic provisioning of elite sportsmen-shooters without CEA16 technology of gestures’ identification. Our results expand significantly the data of other studies [3, 4, 5].

The prospects of other findings in this direction imply addition of new systems to controller of model CEA16. Practical recommendations: for registration space-time parameters direct indicators of model CEA16 to exchange buffer (pressing key PrtSc) and insert it in addition (Paint, Writer, pressing key Shift+Insert). In the process of the model’s adjustment it is necessary to see device in action without touching keyboard, mouse or screen.

The next important moment is determination of
for individual gestures and sensitivity parameters to meet own technical-tactic actions.

Thus, scientific information about dynamic of athlete’s micro movements in Olympic exercises Rapid Fire Pistol and Air Pistol has been developed.

Conclusions
In the present work we have solved the problem of contactless remote registration of athlete hand’s micro movements in the process of pistol shooting in fulfillment Olympic exercises.

The problem has been solved with the help of innovative remote method of computer express-analysis of hand’s coordinate changes by vertical, horizontal and sagittal axes simultaneously. Earlier it was impossible in practice and such information is not mentioned in scientific literature.

We have tested innovative model of contactless registration of athlete hand’s movements in the process of Olympic pistol exercises’ fulfillment.

The values of registered hand’s micro movements in pointing position are as follows: vertical oscillations – 1.931÷1.990 mm; horizontal oscillations – 1.226÷2.042 mm; sagittal micro movements – 3.124÷5.099 mm; velocity of hand’s movement is 11.548÷14.343 mm/sec.

Conflict of interests
The author declares that there is no conflict of interests.

References:
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Body composition versus body fat percentage as predictors of posture/balance control mobility and stability among football players under 21 years

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Abstract

Purpose: Overhead athletes require a delicate balance of shoulder mobility and stability in order to meet the functional demands of their respective sport. While musculoskeletal symptoms (LBP) [1] is one of warning against the consequences recorded in abnormal posture, bending, twisting, gardening and exercise levels among the sportsmen. Based on this theorem, the current study aims to determine the strong factor which affects mobility and stability among soccer players under 21 years.

Material: 163 male players qualified from the Algerian football championship, engaged in the present study, selected by the intentional manner their average age 19.56±1.22 years. They were tested by saving tests (Body Fat Percentage (BFP) - Abdominal test (Abdo) - Modified Bass Test of Dynamic Balance (DB) and standing balance (SB)). As a statistical model, we chose regression analysis to predict the superiority of the variables chosen in the current study.

Results: Based on the analysis statistics, we confirm:
- The high percentage of BFP is a great risk on the levels strengthens abdominal.
- The maintenance of stability (SB) depends on the additional BFP associated with the BMI ratio as being higher factors predicting the total amount of body weight related to the risks of instability.
- Maintaining dynamic mobility (DB) with respect to the displacement of the centre of gravity and its base support in the motion chain is based on excess body fat (BFP) in relation to body mass index (BMI) and Abdominal muscle strengthening levels (ABDO), as higher factors predicting the amount of weight gain.

Conclusions: Founded on the variances acquired by the search, we highlight the relationship between body mass index (BMI) and body fat percent (BFP) as betters index predicting the influence of total amount body weight on mobility and stability among soccer players up to 21 years age. Evidence guide us to recommend, the evaluation of body composition as a part of body management and control. Where strong relationships between BMI and BFP suggests the anomalies postural, muscle coordination, movement control, balance and awareness of body position in both the tests.

Keywords: Body composition, Body Fat Percentage, posture/balance control, players, football.

Introduction

Understanding control processes to maintain the stability or mobility of movements, it’s an essential objective of studies that attempt to treat musculoskeletal system problems [2]. However, mobility has been reported in athletes as adaptive structural changes to the joint resulting in the extreme physiological demands of the activity. Whereas these structural adaptations compromise stability, exposing the athlete to shoulder injuries [3] set by clinical studies in LBP as higher prevalence among medical practitioners than any other musculoskeletal symptoms [4]. Thus, a sports studies indication the back pain as the frequent injury occurred in college football players (27%), artistic gymnasts (50%), and rhythmic gymnasts (86%) [5]. While Laura Purcell, et al reported musculoskeletal symptoms [6] as a risk of the limited body alignment function related to the fix positions [7]. In case of the current study we referred to footballers, among whom low back injury was the most common and most common injury [8]. Based on the warning of health problems [9], which reports that the lifestyle experience decreased energy, after more than 25 minutes causing neck and back pain. Admit by Teen-Hang Meen, et al [10] in maintaining a standing posture for long periods, which leads to static muscular efforts, resulting in the back and headrest carriage, triggering to the musculoskeletal disorders [11], approved by prevalence studies in the significant musculoskeletal pain related to the quality of lifestyle [12]. The case of contact sports, repetitive flexion, extension, and torsion, which are the most injuries correlated to low back pain in the sports practises, suggesting athletic fitness as protective [13] of these injuries. Through this review of the literature, the present study was intended to investigate the impact of follow-up body mass index and body fat percent control as a predictor of these injuries. Moreover, in one hand, our hypotheses based on the confirmation, that the sports participation cannot guarantee physiological body mass and body composition [14], seen the BFP is not down to 5% among the athletes he/she wants to maintain or improve its performance [15]. Well, On the other hand, we criticise the procedure practised by the Algerian selectors which based on trainers’ intuition, without taking into account anthropometric measurements [16]. Some similar studies avoid these methods and strategies and require the coach to use scientific methods [17]. The observed musculoskeletal symptoms require a specific program (evaluation and training).

On its foundations, our background theoretical based on medical studies, which admits that the human spine was
Materials and methods

Study Protocol and Subjects

Protocol

To achieve this goal, we based on the indication, which agrees that the prevalence of low back pain is associations with body fatness, fat distribution and height [19]. Where athletes are at greater risk of sustaining a lumbar (lower) spine injury due to levels of physical activity [20] injury as lots of stress undergoes to the spine, well the absorption of pressure, twisting, turning, and even the bodily impact among the football players. Therefore, sports participation cannot guarantee physiological body mass and body composition, and it is necessary to prescribe an exercise targeting body mass and fat control according to [14].

Subjects

The subjects were 163 male soccer players up to 21 years age in the Algerian football championship participated in the present study. Their average age was 19.56±1.22 years. They were tested by saving tests (Body Fat Percentage-Abdominal Strength - Modified Bass Test of Dynamic Balance and standing balance). To exclude the effect of sex on data, all subjects are male. None of the subjects had historically of inscrutable visual defects, vertigo, motor paresis or sensory deficits. Participation in the current study aimed to examine the superiority of BFP vs BMI factors to predict the effect of mechanical body composition on fixed and mobile balance among soccer players under 21 years. In order to provide baseline information for future analytical studies, our aims are to describe the correlation between body mass and fat control as part of the body-weight management and their consequence on posture/balance control in fixed and dynamic positions.

Testing Protocol

Our choice is based on the indication that generally having poor posture and mechanics, the abnormal posture becomes apparent. Whereas examining posture in a static position allows an unobstructed view of all postures elements. Where the correct posture minimises stress on muscles, bones, and joints while incorrect posture places abnormal stress on these structures [21].

✓ Measurements of standing balance (SB)

Objective

To monitor the development of the player’s ability to maintain a state of equilibrium (balance) in a static position, see fig 1. It shows standing balance (SB).

• Required Resources

To undertake this test, you will require Stopwatch and an assistant.

To conduct the test:

  o The player stands comfortably on both feet with their hands on their hips.
  o The player lifts the right leg, places the sole of the right foot against the side of the left ankle and closed both eyes.

  o The assistant gives the command “GO”, starts the stopwatch and the player raises the heel of the left foot to stand on their toes. The player is to hold this position for as long as possible.
  o The assistant stops the stopwatch when the player’s left heel touches the ground or the right foot moves away from the left knee. The assistance records the time.

✓ Modified Bass Test of Dynamic Balance (DB)

This multiple hop test requires that 1-inch (2.5 cm) tape squares are laid out in a course as shown in figure 1. The subject is required to jump from square to square, in numbered sequence, using only one leg. The hands should remain on the hips. On landing, the subject remains to look face straight ahead, without moving the support leg, for five seconds before jumping to the next square. See fig. 2. Shows Dynamic Balance (DB).

  o Scoring: the result is recorded as either a success or fail. A successful performance consists of hopping to each tape mark without touching the floor with the heel or any other part of the body and holding a static position on each tape mark for five seconds without exposing the tape mark.

✓ Abdominal tests (Abdo)

The abdominal test measures the muscular strength and endurance of the abdominal muscles and hip flexors for 1 min recording the number of repetitions practised by the athlete [24] [25].

Statistical Analyses

Data tests obtained shows, on one hand, that our soccer players are allocated according to them Body Fat Percentage Categories, Athletes and Fitness. As the body mass index our total sample is categories Underweight = <18.5, Normal weight = 18.5–24.9 and Overweight = 25–29.9. In other hand, all the variables chosen to study accepts the normal distribution and homogeneity. Presented as a means ± standard deviation, Shapiro-Wilk and Levene test. See Table 1. All Regression analysis and the relationships analysed between independent variables and predictors are significant at P ≤ 0.05, confirmed by ANOVA one way, T and the positive Pearson autocorrelation expected by Durbin–Watson which is less than 2 and more than 1. See Table 2,3 and 4.

Results

From the regression analyses relating Strength ABDO and the variables used in the current study Table 2, as Model 1, the program showed that BFP was able to explain the changes in the Strength ABDO, where F and T, R and Durbin–Watson are significant at P < 0.001. Through regression analysis relating standing balance (SB) and the
variables used in the current study Table 3 model 1 and 2, the program showed that BFP and BMI were able to explain the changes in the Standing balance (SB), where F and T R and Durbin–Watson are significant at P < 0.001. While in regression analyses relating dynamic balance (DB) and the anthropometrics variables used in the current study Table 4. Model 1, 2, and 4, the program showed that BFP, ABDO, BMI and weight were able to explain the changes in the dynamic balance (DB), where F and T R and Durbin–Watson are significant at P < 0.001. Although our results link with the Posture Committee of the American Academy of Orthopaedics in 1947, that posture is the regular and balanced arrangement of skeletal components to maintain the body’s support structures against injuries and progressive deformation [26]. However, the function of the spine is divided between the anterior (static) and posterior (dynamic) [27], which mechanically required the intermediate of intrinsic skeletal muscles to protect the spinal column [28] the case of regression analyses Table 2. Whereas the minimal muscle strength in altered posture necessitates the dorsal muscles to improve more effort to maintain the balanced position [29], leading to fatigue, skeletal asymmetry and pain nociceptive stimuli related to extreme muscle strain to maintain posture, confirmed by the literature in the significant relationship between muscle shortness, waist and thigh circumferences, and postural balance type [30], the case of regression analyses Table 2, 3 and 4. Moreover, our results confirm that strong relationship between BMI and BFP are superiors to explain the change in abdominal Strength in stable or fixed positions, as well as mobile positions which required the abdominal Strength related to excess of weight, where these findings are in conformity with the American College of Sports Medicine as an appropriate intervention strategies for Weight Loss and Prevention of Weight Regain for Adults [31].

**Discussion**

The results of the present study based on the norms elaborate by the American Council on Exercise (ACE) as Ideal Body Fat Percentages [32] and BMI Categories according to the normative descript by the National Institutes of Health [33]. Whereas all the variables selected to study, shows that BFP and BMI are superiors to predict

<table>
<thead>
<tr>
<th>Table 1. Shows descriptive Statistic baseline characteristics of the total sample.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variables</strong></td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>BFP (%)</td>
</tr>
<tr>
<td>BMI (KG/m²)</td>
</tr>
<tr>
<td>SB(min)</td>
</tr>
<tr>
<td>DB (min)</td>
</tr>
<tr>
<td>ABDO (n°)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Presents the Results of regression analyses relating Strength ABDO and the anthropometrics variables used in the current study.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>a. Dependent Variable: Strength ABDO</td>
</tr>
<tr>
<td>b. Predictors: (Constant), BFP</td>
</tr>
<tr>
<td>Excluded Variables: Weight, Height, BMI.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3: Presents the Results of regression analyses relating standing balance (SB) and the anthropometrics variables used in the current study.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>a. Dependent Variable: standing balance(SB)</td>
</tr>
<tr>
<td>b. Predictors: (Constant), BFP</td>
</tr>
<tr>
<td>Excluded Variables: Weight, Height and ABDO.</td>
</tr>
</tbody>
</table>

| 2 | 0,91b 0,83 0,83 | | BFP | -12,57 | 0,00 | 401,02 | 0,000c |
| | | | BMI | 3,390 | 0,00 | | | | |
| a. Dependent Variable: standing balance(SB) |
| b. Predictors: (Constant), BFP, BMI |
| Excluded Variables: Weight, Height and ABDO. |

98
reduced mobility and stability in football players under 21 years in the both balance & strength abdominal. View these results, we approve that:

1. The sportsmen are not safe from the augmented of the abdominal fat area accumulation in the abdominal and pelvic regions as an amount of total body, confirmed in Strength ABDO as a decrease of the buttocks muscle strength, which negatively affects habitually body posture and habitually locomotion [34] the case exposed in all regression analyses Table 2, 3 and 4.

2. The overweight grass is associated with an increased body weight gain as a risk connected with poor balance at a higher risk of lower limb injuries [35]. In the case of the current study, we confirm:
   A. Sports participation cannot guarantee the negative effects of body mass and body composition on the physiological roundness [14].
   B. Physical fitness and health evaluated must base on various environmental factors, which need to be considered when we examine the effect of sports participation on body composition and fitness [36]. Mentioned by World Health Organization (WHO) in the use of existing settings such as the national situation and cultural habits for the prevention of overweight and obesity [37].
   C. The stockpiling Fat mass in the middle parts of the hull affects the segmental velocity, degree of mobility, control of balance and decrease of posture stability [38] [39] in the both balanced tests.
   D. Body pain accumulates in abnormalities posture, leads to the decrease of muscle coordination, control of movement, balance, and awareness of body position [40] confirmed in our case in reduce of abdominal strength.
   E. Soccer players with a maximum body fat and BMI are likely carrying excess abdominal fat in their abdomen associated with limitation of their level physical mobility and stability [41] [42].
   F. The prevalence of overweight/obesity in soccer players request interventions of coaches and fitness trainers to monitor the weight changes related to fitness and health levels [43].
   G. Well-evaluated and trained programs at high levels of intensity can achieve favourable changes in body composition during the careers of football players, which can confer benefits for performance and injury prevention [44].

According to the descriptions of health professionals and sports diet specialists, coaches needed to understand the dynamic energy balance and be prepared with effective and evidence-based food approaches to help athletes to achieve their body weight goals [45]. Where the previous confirmed the negative effect of overweight and fatness on physical fitness and the strong relationship between body mass index and body fat percentage suggests the further use of body mass index in adolescent soccer players [43]. Viewing these results, we recommend the control of weight changes which recurs from the coach to improve muscular strength and flexibility and decreasing body fat [46], as well as the need of exercise abdominal, back and pelvic muscles at least 30 minutes daily training programme sessions, without remembering the weight control programs. Moreover, this practice is absent in Algeria football clubs, where our players are

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>Coefficients</th>
<th>T</th>
<th>P</th>
<th>F</th>
<th>P</th>
<th>Durbin-Watson</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.80⁺</td>
<td>0.65</td>
<td>0.64</td>
<td>(Constant)</td>
<td>39.26</td>
<td>0.00</td>
<td>295.21</td>
<td>0.000⁺</td>
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</tr>
<tr>
<td></td>
<td>BFP</td>
<td>-17.18</td>
<td>0.00</td>
<td>15.70</td>
<td>0.00</td>
<td>157.12</td>
<td>0.000⁺</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.81⁺</td>
<td>0.66</td>
<td>0.65</td>
<td>BFP</td>
<td>-3.28</td>
<td>0.00</td>
<td>157.12</td>
<td>0.000⁺</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ABDO</td>
<td>-2.71</td>
<td>0.00</td>
<td>15.06</td>
<td>0.00</td>
<td>109.59</td>
<td>0.000⁺</td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>0.82⁺</td>
<td>0.67</td>
<td>0.66</td>
<td>BFP</td>
<td>-3.00</td>
<td>0.00</td>
<td>109.59</td>
<td>0.000⁺</td>
<td></td>
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<tr>
<td></td>
<td>ABDO</td>
<td>-2.71</td>
<td>0.01</td>
<td>12.80</td>
<td>0.00</td>
<td>109.59</td>
<td>0.000⁺</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>BMI</td>
<td>-2.360</td>
<td>0.02</td>
<td>12.80</td>
<td>0.00</td>
<td>109.59</td>
<td>0.000⁺</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>0.83⁺</td>
<td>0.69</td>
<td>0.68</td>
<td>ABDO</td>
<td>3.39</td>
<td>0.00</td>
<td>90.49</td>
<td>0.000⁺</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>-2.71</td>
<td>0.00</td>
<td>-2.95</td>
<td>0.00</td>
<td>90.49</td>
<td>0.000⁺</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Weight</td>
<td>-2.164</td>
<td>0.03</td>
<td>-2.164</td>
<td>0.00</td>
<td>90.49</td>
<td>0.000⁺</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: dynamic balance (DB)
b. Predictors: (Constant), BFP
c. Predictors: (Constant), BFP, BMI
d. Predictors: (Constant), BFP, BMI, Weight
Excluded Variables: Height.
nominated by the traditional method basing on the “gaze of coach” [47]. The inability of this method lies in Body Fat measurements, which cannot be predicted with the naked eye [16].

In conclusion, our results agree with the evidence that the practice of football requires follow-up on the progress of players through an evaluation program of body management, tracking the change of the weight respectfully to levels physical performance. Therefore, the amount of BFP related to BMI leads to poor posture associated with the fragility of the posture, as well as the weakness of musculoskeletal and balance as physical performance.

Conclusions
Our conclusions support our hypothesis, that body composition and body fat gain are superiors to predict the accumulated fat in the abdominal and pelvic regions at great risk of fatness confirmed by medical Algerian studies in the general population [48]. While the current study reports, that increase of body fat related to BMI ratios, accumulate around the midsection fat, influence the levels of Strength ABDO conducting to decrease of abdominal movement ability, posture control capacity, leading to weekly posture, fatigue, painful muscular tension, poor muscle tone and body joint’s performance [49]. Whereas the level of BFP related to ratios BMI depends on the ability of body joints balance related to a combination of mobility and stability, which needed maximum endurance of trunk torque [50].

From the considering that the spine tasks lie in supporting the back muscles, ligaments, facet joints, body of the vertebrae and the disks [51], the current research recommended, the evaluation of body fat related to BMI in comparing to the optional physical fitness (mobility and stability), which allows coaches to assess and condition the elite performance and design evaluation and training programs [52]. Moreover, the dynamically balanced posture requires the gymnastic sessions to develop strength, balance, speed, suppleness, stamina and core body skills, as well as the effect of correcting muscle imbalances; improving posture, coordination, balance, strength, and flexibility correlated to the effectiveness muscle performance; dynamic trunk and extremity strength, coordination, and endurance.

However, these practices request from our coaches, in on hand to integrate exercise targeting body mass and fat control, more than 15–30 min to perform body alignment in the standing position as well as dynamic mobility related to establishing the centre of gravity in motion. Well, on the other hand, the necessity to evaluate the excess body composition, based on body fat percent as a control of weightiness related to optimal performance [53].

Conflict of interests
The author declares that there is no conflict of interests.

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