Respiratory parameters efficiency in sports results among 14-year old male and female swimmers

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Annotation:
The aim of this paper was to test fitness levels of chosen parameters in the respiratory system in comparison to sports results in a group of 100m medley 14-year old male and female swimmers. The main measurement method was based on immediate observation of the following variables: a) The fitness level of particular parameters in the respiratory system, b) The level of swimming fitness. Based on the detailed analysis of the chosen respiratory parameter levels among 14-year old male and female swimmers in relation to their sports result in 100m medley distance, the following general statements have been formulated: the average levels of the chosen respiratory parameters estimated, in most of the cases, above average, especially among female swimmers.

Key words: swimming efficiency, respiratory parameters, sports results.

Introduction

...A sport result conjoins an athlete’s capabilities developed in conscious actions in order to accomplish a physical task, which is regulated by rules of a particular sports discipline. A result is developed in an ongoing and conscious training process which leads to an athlete’s development. Because of this it is understood as a course of training in a particular sport. A sports result shows both hereditary and acquired “... Prus (2005, 38).

In swimming, as well as in numerous other disciplines, individual sport results are shaped by predispositions in a number of factors. The main ones include: overall health, age, sex, training tenure, quality and quantity of training, lifestyle, psychological features (level of motivation, moral support), and will features (peristence, strong will, self-command) Prus, Zając (1999), Dybińska, Kucia – Czyszczon (2007).

According to Grzegorz Prus (2005) a sports result is a final display of individual biological abilities including:
- hereditary factors manifested in internal and external features (morphological, physiological, psychological);
- environmental and sociological influence that shapes individual development and their hereditary predispositions (i.e. financial situation, time constraints);
- influence of training understood as a process of applying long-term training and competitions routine which is divided into stages. Training capacity and intensity in the training stages is adjusted to an athlete’s training tenure.

All the above mentioned – hereditary factors, natural and sociological environment, and the course of training – affect and influence one another. It is not possible to establish accurately how far they really influence sports results. However, to achieve high results in professional sports, the influence of hereditary factors is vital and undisputed.

An athlete’s physiology is also very crucial in achieving a sports result. Swimming is an endurance discipline that develops the circulatory and respiratory systems. One of the main demands in aspiring to high-level results is to secure energy deposits. This aspect is particularly important in competitive sport.

A sports result depends on Rygula (2000):
- the level of somatic factors,
- the level of functional factors,
- the scope of technical parameters,
- the scope of individual qualities,
- the level of motoric parameters (fitness level and level of co-ordination),
- the scope of tactical parameters.

One of the most vital elements influencing the overall sports result is physical fitness level, which helps maintain the internal balance at the time of performing a physical exercise. In more intensive efforts, i.e. during training sessions, aerobic efficiency is the most vital factor. Aerobic efficiency means the ability to perform an effort for a period of time using large muscle groups and without imminently increasing fatigue Görski (2006). There are a number of physiological indicators that can be used to indicate physical fitness level. One of the most popular is maximal oxygen consumption (VO2max). This indicator specifies the maximum quantity of oxygen that
an individual’s body can absorb in one minute in order to produce energy. The amount of maximal oxygen consumption is determined by a number of elements related to: oxygen consumption in lungs, oxygen transport in blood and energy metabolism in muscle. The respiratory system, extraordinary in its structure and functioning, provides efficient gas exchange and constant co-operation with the circulatory system. Breathing is a process of an on-going bilateral gas flow between an individual’s body and the outer environment. The oxygen acquired from the air is then transported further to cells and needless carbon dioxide produced in metabolic transformations is later moved outside of the system.

The environment in which swimming as a discipline takes place is quite unique, for it is water. Therefore alongside the circulatory system, the respiratory system also plays a vital role in swimming. It is both training and the environment itself that stimulate and help develop the respiratory system. Breathing under water means fighting a liquid which is 820 times thicker than air, which helps developing respiratory fitness level Dybińska (2009). During inspirations a chest expands and faces water pressure, which requires breathing muscles to work more efficiently. The same happens during exhalations, which occur seamlessly in normal conditions. In under water breathing, on the other hand, exhalation requires more efficient use of available oxygen and coping with carbon dioxide deposits awaiting to be transported out of the system. The dilated vital capacity of lungs is caused by diminished deposit capacity, which can constitute 10% of the total.

Because of the larger number of alveoli engaged in breathing, the overall lung ventilation capacity improves Czabański et al. (2003), Dybińska (2009). The amount of air found in lungs is also crucial as it is considerably lighter than water. This leads to the conclusion that swimmers’ larger vital lungs capacity has a positive influence on their swimming ability and their body as a whole. Even during an inhalation itself the uplift pressure increases enough to fight the force of gravity Czabański et al. (2003). The importance of an efficient respiratory system in physical efforts, especially in a water environment, is unquestionable.

Having the above in mind, the main inspiration to undertake the following research was to find a correlation between a sports result and individual swimmer’s functional abilities formulated by efficiency parameters of the respiratory system.

The aim

The aim of this paper was to test fitness levels of chosen parameters in the respiratory system in comparison to sports results in a group of 100m medley 14-year old male and female swimmers from the Malopolska (Lesser Poland) region.

The thesis of this paper is as follows: 1. Is there any correlation between sports results and functioning of respiratory system in the examined group of 14-year old girls and boys and if so, what is the level of the correlation?

The research hypothesis was therefore: It is presumed that there is high level of correlation of chosen parameters in the respiratory system and swimming capability of 14-year old male and female swimmers, yet there is gender differential in the level of correlation. Among 14-year old boys the correlation of chosen parameters is observed more frequently than in the group of girls.

Material and method

The observations presented were a part of a large research project carried out by The Faculty of Theory and Methodology of Water Sports at The Academy of Physical Education in Cracow and performed by the authors of this paper. The research project was registered as a Promoting Research Work No N404 177235 by the Polish Ministry of Higher Education and Science.

The study took place at the swimming pool by the Academy of Physical Education in Cracow, Rogozińskiego Street No 12, on the 7th and 8th of February 2009.

The date for the study fell just slightly after the Polish Junior Championships that took place on 16-18th of January 2009. In this period the group was following a training programme, at the time being in a transition stage of yearly macro cycles. The main aim of this stage was to actively rest and recover from the training load, to maintain fitness at a certain level, and for psychological restoration, which leads to increased motivation Platonow (1997). These actions are to ensure a certain level of preparation for the next stage of the training cycle.

The main measurement method was based on immediate observation of the following variables:

1. The fitness level of particular parameters in the respiratory system – formulated by a spirometrical test.

2. The level of swimming fitness – formulated by a result in a 100m medley distance.

The total of 33 athletes who participated in the study were, including 18 males and 15 females, all 14-years old and representing the Lesser Poland region.

The examination of the fitness level of particular parameters in the respiratory system was performed using a MicroLoop spirometer made by Micro Direct. Each athlete was informed about the purpose and the course of the test before the examination.


- Vital Lung Capacity (vital capacity) (VC) – which is the capacity of air being the difference between the deepest inspiration and the maximum exhalation.
- Forced Expiratory Volume – in this examination the following extra parameters were tested:
- Forced Expiratory Volume in 1 second (FEV1) – air capacity exhaled in the first second of a maximum large and maximum fast exhalation after a full inspiration.
- Forced Vital Capacity (FVC) – the largest air capacity exhaled at the maximum exhalation effort after a full inspiration.
Peak Expiratory Flow (PEF) – the maximal flow registered during testing of the Forced Expiratory Volume. Based on the results acquired in the examinations the following indicators were calculated Lebecque, Kiakulanda, Coates (1993):

- **Tiffeneau index (FEV₁/VC)**, which shows the ratio of Forced Expiratory Volume in 1 second (FEV₁) to Vital Capacity (VC); it is calculated in the following equation:

\[
\text{Tiffeneau index} = \left(\frac{\text{FEV}_1}{\text{VC}}\right) \times 100\%
\]

- **pseudo – Tiffeneau index (FEV₁/FVC)** is the ratio of Forced Expiratory Volume in 1 second (FEV₁) to Forced Vital Capacity (FVC); the following equation can be used to count it:

\[
\text{pseudo - Tiffeneau index} = \left(\frac{\text{FEV}_1}{\text{FVC}}\right) \times 100\%
\]

The testing of the parameters of the respiratory system was conducted based on the required procedures and recommendation for this kind of examination (www.igichp.edu.pl).

The interpretation of Tiffeneau index was made based on the following criteria (www.docedu.klrwp.pl):

- 65% and less – result below standard;
- 65% – 85% – standard result for a healthy person;
- 85% and above – result above standard.

The **voiced swimming fitness level** was measured based on the following swimming activity:

- Test distance of **100 m medley**.

Each athlete swam the distance individually on a separate lane at his or her maximum speed; the start initiated from starting blocks, the start and the turns at each lap took place according to FINA swimming regulations (2009). The time was measured electronically by the Multiple Camera System for Registration of Swimming Technique (WSRTP) Kucia-Czyszczoń, Dybińska (2009), www.l-t-p.pl.

The correlation between chosen parameters of the respiratory system and the sports result in a 100m medley distance was sought using Pearson linear correlation by calculating the correlation coefficient (r) in Statistica 9 PL programmed Cięszczyk, Boichanka (2008).

**Test results**

After evaluation of the athletes’ sports results, it has been confirmed that all the athletes participating in the test achieved results qualifying them to competitive classification statuses (according to the criteria defined by the Polish Swimming Association, PZP), of which the 2nd Classification Status was achieved by a vast majority of female swimmers (67%) compared to 33% of male swimmers. This is opposed to the 3rd Classification Status being achieved by a majority of male swimmers (67%) and 33% of female swimmers.

Taking into consideration the examination material, in the first place the spirometrical results related to executive values (standard values) were measured.

### Table 1: Statistical values of measured respiratory parameters – female swimmers

<table>
<thead>
<tr>
<th>No</th>
<th>Parameter</th>
<th>( \bar{X} )</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>R</th>
<th>V%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VC</td>
<td>4.06</td>
<td>0.58</td>
<td>3.29</td>
<td>5.15</td>
<td>1.86</td>
<td>14.24</td>
</tr>
<tr>
<td></td>
<td>VC stand.</td>
<td>4.07</td>
<td>0.26</td>
<td>3.77</td>
<td>4.65</td>
<td>0.88</td>
<td>6.42</td>
</tr>
<tr>
<td>2</td>
<td>FEV₁</td>
<td>3.66</td>
<td>0.51</td>
<td>2.89</td>
<td>4.74</td>
<td>1.85</td>
<td>13.86</td>
</tr>
<tr>
<td></td>
<td>FEV₁ stand.</td>
<td>3.35</td>
<td>0.31</td>
<td>2.93</td>
<td>3.92</td>
<td>0.99</td>
<td>9.14</td>
</tr>
<tr>
<td>3</td>
<td>FVC</td>
<td>4.05</td>
<td>0.59</td>
<td>3.11</td>
<td>5.19</td>
<td>2.08</td>
<td>14.69</td>
</tr>
<tr>
<td></td>
<td>FVC stand.</td>
<td>3.68</td>
<td>0.37</td>
<td>3.17</td>
<td>4.37</td>
<td>1.20</td>
<td>10.18</td>
</tr>
<tr>
<td>4</td>
<td>PEF</td>
<td>366.13</td>
<td>73.56</td>
<td>264.00</td>
<td>484.00</td>
<td>220.00</td>
<td>20.09</td>
</tr>
<tr>
<td></td>
<td>PEF stand.</td>
<td>449.53</td>
<td>31.23</td>
<td>408.00</td>
<td>503.00</td>
<td>95.00</td>
<td>6.95</td>
</tr>
<tr>
<td>5</td>
<td>FEV₁/VC</td>
<td>90.43</td>
<td>6.44</td>
<td>77.78</td>
<td>102.78</td>
<td>25</td>
<td>7.12</td>
</tr>
<tr>
<td>6</td>
<td>FEV₁/FVC</td>
<td>96.86</td>
<td>5.15</td>
<td>79.88</td>
<td>96.86</td>
<td>16.98</td>
<td>5.31</td>
</tr>
</tbody>
</table>

**Table key:**

- VC – Vital Capacity
- VC stand. – Standard Vital Capacity (measured by the spirometer)
- FEV₁ – Forced Expiratory Volume in 1 second
- FEV₁ stand. – Standard Forced Expiratory Volume in 1 second (measured by the spirometer)
- FVC – Forced Vital Capacity
- FVC stand. – Standard Forced Vital Capacity
- PEF – Peak Expiratory Flow
- PEF stand. – Standard Peak Expiratory Flow (measured by the spirometer)
- FEV₁/VC – Tiffeneau index
- FEV₁/FVC – The ratio of Forced Expiratory Volume in 1 second (FEV₁) to Forced Vital Capacity (FVC)
Tiffeneau index (FEV₁/VC) considerably exceeded the standard value (it equaled 90.43%).

Among male swimmers, as well as among female swimmers, (Table 2) the average values of respiratory parameters were higher than the predicted average, however Vital Capacity (VC) and the Peak Expiratory Flow (PEF) were slightly lower. Both Tiffeneau index (FEV₁/VC and FEV₁/FVC indicator (The ratio of Forced Expiratory Volume in 1 second (FEV₁) to Forced Vital Capacity (FVC)) – reached values of 85% and above, which is above average.

Investigating the correlation between the results of the swimming fitness test (shown by sports result in 100m medley distance) and the following parameters of respiratory system fitness:
- Vital Capacity (VC),
- Forced Expiratory Volume in 1 second (FEV₁),
- Forced Vital Capacity (FVC),
- Peak Expiratory Flow measured in a maximum expiration (PEF),
- Tiffeneau index (FEV₁/VC)
- FEV₁/FVC indicator
was done using Pearson linear correlation by calculating the linear correlation indicator (r).

The above analysis of correlation between the results in 100m medley and the chosen parameters of the respiratory system among female swimmers (Table 3), shows that of the factors tested the only significant correlation (at a high level) was the relation between the swimming test and Forced Expiratory Volume in 1 second (FEV₁). In this correlation the indicator (r) equaled -0.53 (p=0.05) (Pic. 1). In all other cases there was no statistically significant relations, however between the swimming fitness test and Peak Expiratory Flow (PEF) an average correlation was observed, and the indicator (r) amounted to -0.48, which is at the borderline of statistical relevance.

In the group of male swimmers there was a significant correlation between the results of the swimming fitness test and the following parameters (Table 4, Pict. 2, 3, 4, 5):
- Forced Expiratory Volume in 1 second (FEV₁), where the correlation indicator (r) equaled -0.67 (p = 0.05);
- Forced Vital Capacity (FVC) – correlation indicator (r) equaled -0.65 (p = 0.05);
- Vital Capacity (VC), where the correlation indicator (r) reached the value of -0.61 (p = 0.05).

In one case – the result of the swimming test and the Peak Expiratory Flow (PEF) there was an average correlation and the correlation indicator (r) equaled -0.47, p=0.05, and between Tiffeneau index (FEV₁/VC) the correlation was statistically insignificant (r -0.17).

Discussion
In competitive swimming each athlete should pursue a level qualifying for Classification Status. A skillful use of
Pic. 1. Dispersion chart: 
Swimming fitness test vs. Forced Expiratory Volume in 1 second – female swimmers

Pic. 2. Dispersion chart: 
Swimming fitness test vs. Vital Capacity – male swimmers

Pic. 3. Dispersion chart: 
Swimming fitness test vs. Forced Expiratory Volume in 1 second – male swimmers
the athlete’s potential is the key to success. Financial and technical background is equally important. Among the large number of young swimmers only a few will reach a high competitive level or mastery. Achieving this level will only be possible when applying a variety of training treatments and creating the right environment for development of a swimmer’s talent. Success is a result of long-term training, which requires planned and rational actions to be taken Dybińska-Kucia (2007).

The road to the level of sports mastery is a multi-level process, where each stage is essential. A young swimmer’s body adapts quickly to the changes, which may mean one of the important stages can be omitted. This can result in training not bringing any significant results, and potential being wasted Bartkowiak (1999).

Beyond doubt, the water environment in swimming differentiates this discipline from all the others. What is worth mentioning is the breathing itself, which is, to some extent, restricted under water. It therefore proves that the respiratory system plays an exceptional role in swimming.

Correct respiration is one of the symptoms of maintained circulation, which also tells about life condition Andres (2005). It is worth considering whether it is possible to improve the system responsible for air ventilation for training purposes and to what extent these changes may be accomplished.

It seems that a well-working respiratory system can be a vital factor in determining the final sports results of athletes in the competitive rivalry Sozański (1994). The aim of this article was to determine the value of particular parameters and respiratory indicators among young swimmers and their relationships with swimming fitness tests.
swimmers and their relation with the final sports results. The proposed thesis was negatively verified, because the correlations between the chosen parameters of the respiratory system and the swimming fitness of the tested girls and boys in most of the cases were not statistically significant. The only variable which proved a high level of correlation (p<0,05), expressed in FNA grading scale, was the Tiffeneau index. **The conclusion**

Based on the detailed analysis of the chosen respiratory parameter levels among 14-year old male and female swimmers, Malopolska (Lesser Poland) region representatives, in relation to their sports result in 100m medley distance, the following general statements have been formulated:

1. The average levels of the chosen respiratory parameters of the 14-year old male and female swimmers estimated, in most of the cases, above average, especially among female swimmers.

2. One of the more important respiratory parameters, indicating the functional efficiency of the respiratory system, Tiffeneau index, reached high values – 90,47% among females and 85,49% in case of female and male swimmers respectively. The only variable which proved high level of correlation (p<0,05), expressed in FNA grading scale, was the Peak Expiratory Flow (PEF) indicator results confirmed positive results of the respiratory parameters, as the indicator reached the values above average – calculated at 90,6% and 85,49% in case of female and male swimmers respectively.

3. The correlation analysis between the sports result (of 100m medley distance) and the chosen respiratory parameters in the examined group proved a significant correlation occurred only in one case – between the swimming fitness test and the Forced Expiratory Volume in 1 second (FEV1). In all other cases no statistically significant correlation was observed.

4. On the other hand, the correlation between the chosen parameters in the case of male swimmers was significant in 3 cases. There was a high level of correlation between the result of the swimming test of 100m medley and the Forced Respiratory in 1 second (FEV1); Forced Vital Capacity (FVC) and Vital Capacity (VC). In one case, between the swimming fitness test and the Peak Expiratory Flow (PEF) there was an average level of correlation and the correlation indicator (r) -0,47, p = 0,05. Therefore in this case, the thesis was positively verified.

5. It seems that the results of this examination, apart from having a theoretical function, can be used in practice as they can help coaches and instructors diagnose, forecast, analyze or plan the training process for young swimmers, especially in relation to shaping of the functional abilities of the respiratory system.

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