RELIABILITY AND VALIDITY OF A MODIFIED FIELD TEST FOR THE EVALUATION OF AEROBIC PERFORMANCE

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Abstract:
The purpose of this study was to assess the reliability and the validity of a modified version of the Multi-stage Shuttle-Run Aerobic Test 20m. The proposed version is a hexagon with 10m side distances each named Hexagon Multi-Level Running Aerobic Test 10m. The same parameters (ending level, maximum speed and heart rate at the finish) were measured and the VO2max was estimated in both tests using the Multistage Shuttle-Run Aerobic Test 20m protocol and tables. For the proposed test the reliability evaluation was applied on a sample of 18 students (age 20.8±0.9yrs) twice with a 48h time interval, giving high correlations in maximum speed and VO2max (r=0.99) and ending level (r=0.98). For the Hexagon Multi-Level Running Aerobic Test 10m the validity assessment of the measured variables of this test were compared with the same variables of the Multistage Shuttle-Run Aerobic Test 20m in 62 trained adolescents (age 13.7±0.7yrs). The validity coefficients for all the variables between the two tests were r=0.86 (p<0.01). Furthermore, the participants’ performance profile was significantly higher in the proposed version, (p<0.05) while the mean VO2max of adolescents was significantly higher in this test than in the prototype Multistage Shuttle-Run Aerobic Test 20m (46±6.2 vs 40.8±4.9ml/kg · min), (p<0.05). Conclusively, it can be inferred that the Hexagon Multi-Level Running Aerobic Test 10m is not only a reliable and easy to use test but also, compared to the valid Multistage Shuttle-Run Aerobic Test 20m, it can be an objective test for the evaluation of aerobic performance in adolescents.

Key words: VO2max, running, shuttles, hexagon

Introduction
Physiological monitoring can provide the sport scientist with an objective means of assessing the performance capability of an individual. The evaluation of aerobic performance defines the indicators of health and superiority to many daily activities. Undoubtedly, the most accurate measurement of aerobic performance in the form of maximum oxygen uptake (VO2max) takes place in research laboratories. The determination of VO2max by indirect calorimetry is one of the most commonly performed measurements for aerobic capacity (Morrow, Jackson, Disch, & Mood, 2000). However, this form of assessment has disadvantages in terms of availability, cost and time (Armstrong, Williams, & Ringham, 1998). A valid field test measuring aerobic performance could eliminate many of the laboratory restrictions (Noonan & Dean, 2000). The Multistage Shuttle-Run Aerobic Test 20m (Leger & Boucher, 1980; Leger & Lambert, 1982; Tokmakidis, Leger, Mercier, Peronnet, & Tibault, 1988; Leger, Mercier, Gadoury, & Lambert, 1988; Brewer, Ramsbottom, & Williams, 1988) and the 12-minute run test (Cooper, 1968) are two widely reported and commonly used field test of aerobic capacity. The low validation of the 12-minute run tests (Leger & Lambert, 1982; Jackson, DerWeduwe, Schick, & Sanchez, 1990) and the significant correlation (r=0.89) between the estimation of VO2max from the Multistage Shuttle-Run Aerobic Test 20m (MSRAT20m) and VO2max laboratory measurements (Leger & Gadoury, 1989) leads to the fact that the MSRAT20m is one of the most valid and well accepted tests for the estimation of aerobic performance in a variety of setting rankings (i.e., physical education, adult fitness programmes and specific sports performance testing). The above test is based on a series of shuttle runs between two lines exactly 20m apart, keeping the participant at running pace with a series of audio signals. The participant stops when he or she can no longer maintain the prior determined running speed while the aerobic performance is estimated according to the final level and number of shuttles completed (Ramsbottom, Brewer, & Williams, 1988).
From its initial design until today a number of modifications have been applied to the MSRAT20m (Tokmakidis et al., 1988; Nicholas, Nuttall, & Williams, 2000; Flouris, Tsiotras, & Koutentakis, 2003). The scientific hypothesis was that by changing the shuttle and intermittent way of running during the MSRAT20m to a curvilinear continuous running motion of the Hexagon Multi-Level Running Aerobic Test 10m (HMRAT10m) the participants will have a positive effect in maximum aerobic capacity as a result of the running economy yielded from the modified version. For this reason the aim of this study was to evaluate the reliability and the validity of a modified version of the multistage running field test for the prediction of maximal aerobic performance in young adults and adolescents.

Methods

Participants

In the preliminary study the participants in the HMRAT10m reliability test-retest trials consisted of eighteen (n=18) healthy PE students (10 males & 8 females), aged 20.8±0.9yrs. In addition, sixty-two adolescents (n=62), 39 males and 23 females, aged 13.7±0.7yrs, with experience in athletics, participated in the main study. Both PE students who participated in the HMRAT10m reliability study as well as the adolescents who took part in the main study were volunteers and gave their written consent. Prior to the beginning of the testing procedures oral instructions were given about the nature of the research as well as what the participants should avoid doing before and after the measurements. The adolescents’ physical and anthropometric data of the main study were obtained as part of the initial screening (Table 1).

Experimental design

The modified version is based on a hexagon and is named Hexagon Multi-Level Run Aerobic Test 10m (HMRAT10m). A hexagon was drawn with white lines on the running surface with each angle distance of 10m, the vertex of the hexagon 45° while the other four vertexes were 150° (Figure 1). In practice the HMRAT10m is a continuous incremental speed clockwise running task consisting of six straight lines, with the distance from angle to angle 10m. This version of the design was based on the assumption that the hexagon with these two types of angles (45° & 150°) could be the link between a) the forward and backward directions intermittent MSRAT20m and, b) the fully forward in running direction and continuous aerobic capacity test which takes place on a track. The participants during the HMRAT10m were instructed to run clockwise from the start angle at a running speed based on the sound bleeps of the series of audio signals of the MSRAT20m protocol (Ramsbottom et al., 1988). The participants, in groups of three, should aim to be in every 20m or in two angles distance (10+10m) at any sound signal. For any individual who fails twice to reach the 20m angle’s mark at the end of each shuttle, at a given pace of MSRAT20m protocol, the test is terminated. The participants’ maximal oxygen uptake (VO2max) was calculated by using the tables for predictive VO2max values (Ramsbottom et al., 1988).

Table 1. Main participants’ physical and anthropometric characteristics (mean±SD)

<table>
<thead>
<tr>
<th></th>
<th>Age (yrs)</th>
<th>Body mass (kg)</th>
<th>Stature (cm)</th>
<th>Body Mass Index (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n=62)</td>
<td>13.7(0.7)</td>
<td>56.4 (11.3)</td>
<td>163 (0.8)</td>
<td>21.22 (10.8)</td>
</tr>
<tr>
<td>Males (n=39)</td>
<td>13.6(0.7)</td>
<td>56.3 (10.9)</td>
<td>162 (0.1)</td>
<td>21.48 (11.3)</td>
</tr>
<tr>
<td>Females (n=23)</td>
<td>13.7(0.8)</td>
<td>56.5 (12.2)</td>
<td>165 (0.5)</td>
<td>20.75 (8.8)</td>
</tr>
</tbody>
</table>

Figure 1. Schematic representation of the HMRAT10m.

Experimental protocol

All the tests were conducted in a school sports ground with the subjects being instructed to refrain from heavy exercise at least 24 hours before each testing session. The participants of the preliminary measurements for the reliability and repeatability of the modified version completed the HMRAT10m twice, with a standard of 48 hours interval between each session. The two research sessions were carried out for all the participants for the same time and on the same running surface and in similar environmental conditions.

For the validity evaluation, participants were randomly assigned to a test order of HMRAT10m and MSRAT20m. The reason for choosing the MSRAT20m and not a laboratory treadmill VO2max test was that
the investigator wanted to find out how the kinetic and kinematic characteristics of each test could affect the $\text{VO}_{2\text{max}}$ by using the same aerobic performance measurement protocol in both tests. The trials were held in two sessions with a difference of at least two days in similar testing protocol and ambient temperature (~20°C) and with a random counterbalanced turn. Testing procedures in both tests were based on the protocol and instructions of MSRAT$_{20m}$ (Ramsbottom et al., 1988).

A portable CD player, a CD supplied with a booklet, a measuring tape (to measure the 10m and 20m lines), marker cones, a digital chronometer and a heart rate monitor (Polar Electro Sports Tester, S810i, Polar Electro, Kempele, Finland) were used in order to record the performance and physiological measurements. Both MSRAT$_{20m}$ and HMRAT$_{10m}$ were terminated if the subject voluntarily dropped out or did not make the 20m line in two consecutive laps. The final successfully completed level was recorded as the finish while the subjects were instructed to complete as many levels as possible. The participants’ maximum speed ($S_{\text{max}}$) obtained in km/h was considered the speed of the final successfully completed level. The predicted $\text{VO}_{2\text{max}}$ in both MSRAT$_{20m}$ and HMRAT$_{10m}$ was calculated relatively to body mass according to the MSRAT$_{20m}$ tables and norms for any individual. In addition, the performance peak heart rate ($HR_p$) was recorded and stored with digital display in order to confirm the participants’ maximal effort immediately after the completion of both tests.

Statistical analysis

Descriptive statistics were applied for the subjects’ physical and anthropometric variables. The nature of the data was the paired variables of one group. The Intraclass Correlation Coefficient (ICC) was applied to estimate the relative reliability (95% CI) between both HMRAT$_{10m}$ measuring variables. The HMRAT$_{10m}$ absolute reliability was reported using both the calculations of coefficients of variation (CV) and standard error of measurements (SEM). The statistical design for the HMRAT$_{10m}$ validity evaluation was based on Pearson’s $r$ correlation analysis. The correlated control $t$ (paired samples $t$-test) was used in order to analyse the performance and physiological data between HMRAT$_{10m}$ and MSRAT$_{20m}$. One-way ANOVA was applied to evaluate the differences between the performance and physiological variables for each test in relation to the participants’ gender. All statistical procedure was based on the statistical package SPSS 14 for Windows. The acceptable level of significance was set at 0.05 and all the results were reported as mean ± standard deviation.

Results

The first observation of the investigator from the reliability testing procedures was that the modified version for the estimation of aerobic performance was easy in use and a very well accepted task by the participants. The test-retest analysis confirmed that the majority of data resulting from HMRAT$_{10m}$ had a high reliability coefficients. The ending level of the HMRAT$_{10m}$ presented an excellent ICC correlation (0.99) in both trials (8.1 vs 8.3). Similarly, high ICC correlation in $S_{\text{max}}$ (0.99), which corresponds to the PE students speed of the final successfully completed level (12 vs 12.1 km/h), was observed between trials during both HMRAT$_{10m}$. In addition, the $\text{VO}_{2\text{max}}$ estimated from both HMRAT$_{10m}$ (47.2 ± 9.1 vs 47.6 ± 9.3 ml/kg · min) presented a reliability coefficient of 0.99 as a result of the above high correlated variables. In contrast, for the performance $HR_p$ of both HMRAT$_{10m}$ the reliability coefficient was acceptable (0.77), while the participants mean $HR_p$ ranged from 191±8.1b/min at the 1st HMRAT$_{10m}$ to 194±9.4b/min at the 2nd HMRAT$_{10m}$. Table 2 illustrates the preliminary study reliability results of the HMRAT$_{10m}$ measured and recorded variables in 18 PE students.

Table 2. Test-retest (mean±SD), coefficient of variation (%), intraclass correlation coefficient (95%CI) and standard error of measurements of the HMRAT$_{10m}$

<table>
<thead>
<tr>
<th>Level (No)</th>
<th>1st HMRAT$_{10m}$ CV*</th>
<th>2nd HMRAT$_{10m}$ CV*</th>
<th>ICC*</th>
<th>95%CI</th>
<th>SEM†</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{\text{max}}$ (km/h)</td>
<td>8.1±3.1</td>
<td>38.3</td>
<td>8.3±3.2</td>
<td>36.6</td>
<td>0.98</td>
</tr>
<tr>
<td>$S_{\text{max}}$</td>
<td>12±1.6</td>
<td>13.3</td>
<td>12.1±1.6</td>
<td>13.2</td>
<td>0.99</td>
</tr>
<tr>
<td>$\text{VO}_{2\text{max}}$ (ml/kg · min)</td>
<td>47.2±9.1</td>
<td>19.3</td>
<td>47.6±9.3</td>
<td>19.5</td>
<td>0.99</td>
</tr>
<tr>
<td>$HR_p$ (b/min)</td>
<td>191±8.1</td>
<td>4.2</td>
<td>194±8.4</td>
<td>4.9</td>
<td>0.77</td>
</tr>
</tbody>
</table>

* Coefficient of Variation
† Intraclass Correlation Coefficient
† Standard Error of Measurements
were reported in participants during the HMRAT_{10m} in comparison to MSRAT_{20m} \((p<0.01)\). The ending level of the HMRAT_{10m} was significantly higher with values of 6.3±2.3 than the MSRAT_{20m} ending level values of 4.3±1.8 \((t=12.9, df=61, 2\)-tailed \(p=0.001)\). Similarly, the \(S_{\text{max}}\) at the finishing point of the HMRAT_{10m} \((11.1\pm1.1 \text{ km/h})\) was significantly higher than the MSRAT_{20m} \((10.1\pm0.9 \text{ km/h})\) \((t=12.9, df=61, 2\)-tailed \(p=0.001)\). Likewise, the \(V_{\text{O}2\max}\) \((46\pm6.2 \text{ ml/kg · min})\) was significantly higher in the HMRAT_{10m} than in \(V_{\text{O}2\max}\) \((40.8\pm4.9 \text{ ml · kg}^{-1} \cdot \text{ min})\) during the MSRAT_{20m} \((t=12.8, df=61, 2\)-tailed \(p=0.001)\). In contrast, slightly higher but not significant differences were found in participants \(HR_p\) at test termination or finishing point at HMRAT_{10m} \((196\pm6.2 \text{ b/min})\) in comparison to MSRAT_{10m} \((194\pm9.7 \text{ b/min})\) \((t=1.3, df=61, 2\)-tailed \(p=0.20)\). The correlation of coefficients between the performance and physiological variables of both tests is presented in Table 3.

### Table 3. Correlation matrix between physiological and performance variables of HMRAT_{10m} and MSRAT_{20m}

<table>
<thead>
<tr>
<th></th>
<th>(V_{\text{O}2\max}) HMRAT_{10m}</th>
<th>(V_{\text{O}2\max}) MSRAT_{20m}</th>
<th>Level HMRAT_{10m}</th>
<th>Level MSRAT_{20m}</th>
<th>(S_{\text{max}}) HMRAT_{10m}</th>
<th>(S_{\text{max}}) MSRAT_{20m}</th>
<th>(HR_p) HMRAT_{10m}</th>
<th>(HR_p) MSRAT_{20m}</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{\text{O}2\max}) HMRAT_{10m}</td>
<td>1 (p&lt;0.01)</td>
<td>0.98(p&lt;0.01)</td>
<td>0.86(p&lt;0.01)</td>
<td>0.98(p&lt;0.01)</td>
<td>0.86(p&lt;0.01)</td>
<td>0.51(p=0.19)</td>
<td>0.99(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
</tr>
<tr>
<td>(V_{\text{O}2\max}) MSRAT_{20m}</td>
<td>1 (p&lt;0.01)</td>
<td>0.82(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.82(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.45(p=0.26)</td>
<td>0.87(p&lt;0.01)</td>
<td>0.28(p=0.28)</td>
</tr>
<tr>
<td>Level HMRAT_{10m}</td>
<td>1</td>
<td>0.86(p&lt;0.01)</td>
<td>0.99(p&lt;0.01)</td>
<td>0.87(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
<td>0.48(p=0.20)</td>
<td>0.20(p&lt;0.05)</td>
<td>0.20(p&lt;0.05)</td>
</tr>
<tr>
<td>Level MSRAT_{20m}</td>
<td>1</td>
<td>0.86(p&lt;0.01)</td>
<td>0.99(p&lt;0.01)</td>
<td>0.87(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
<td>0.48(p=0.20)</td>
<td>0.33(p&lt;0.05)</td>
<td>0.20(p&lt;0.05)</td>
</tr>
<tr>
<td>(S_{\text{max}}) HMRAT_{10m}</td>
<td>1</td>
<td>0.87(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.87(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
<td>0.48(p=0.20)</td>
<td>0.20(p&lt;0.05)</td>
<td>0.20(p&lt;0.05)</td>
</tr>
<tr>
<td>(S_{\text{max}}) MSRAT_{20m}</td>
<td>1</td>
<td>0.87(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.87(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
<td>0.48(p=0.20)</td>
<td>0.20(p&lt;0.05)</td>
<td>0.20(p&lt;0.05)</td>
</tr>
<tr>
<td>(HR_p) HMRAT_{10m}</td>
<td>1</td>
<td>0.99(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
<td>0.48(p=0.20)</td>
<td>0.28(p&lt;0.05)</td>
<td>0.28(p&lt;0.05)</td>
</tr>
<tr>
<td>(HR_p) MSRAT_{20m}</td>
<td>1</td>
<td>0.99(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.97(p&lt;0.01)</td>
<td>0.41(p=0.28)</td>
<td>0.48(p=0.20)</td>
<td>0.28(p&lt;0.05)</td>
<td>0.28(p&lt;0.05)</td>
</tr>
</tbody>
</table>

\(p<0.01\) \(p<0.05\)

As for gender, male adolescents had statistically significant differences than females in aerobic performance in both HMRAT_{10m} and MSRAT_{20m}. According to the measured parameters males during the HMRAT_{10m} performed better than females in relation to MSRAT_{20m} apart from the finishing point \(HR_p\) in which both males and females had similar values (Table 4).

### Table 4. Measured, recorded and calculated data (mean±SD) from HMRAT_{10m} and MSRAT_{20m} adjusted by the adolescents’ gender

<table>
<thead>
<tr>
<th>Test</th>
<th>HMRAT_{10m}</th>
<th>MSRAT_{20m}</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>(P)</td>
<td>Males</td>
<td>Females</td>
<td>(P)</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Level (km/h)</td>
<td>6.7±2.6</td>
<td>4.6±1.9</td>
<td>0.05</td>
<td>5.4±1.4</td>
<td>3.7±1.3</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(S_{\text{max}}) (km/h)</td>
<td>11.3±1.3</td>
<td>10.3±0.9</td>
<td>0.001</td>
<td>10.7±0.7</td>
<td>9.8±0.6</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_{\text{O}2\max}) (ml/kg · min)</td>
<td>47.5±6.8</td>
<td>42±5.1</td>
<td>0.05</td>
<td>43.5±4.1</td>
<td>38.8±3.8</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(HR_p) (b/min)</td>
<td>197.3±6.4</td>
<td>193.7±10.5</td>
<td>ns</td>
<td>197.1±7.9</td>
<td>195.1±5.9</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As for gender, male adolescents had statistically significant differences than females in aerobic performance in both HMRAT_{10m} and MSRAT_{20m}. According to the measured parameters males during the HMRAT_{10m} performed better than females in relation to MSRAT_{20m}. Apart from the finishing point \(HR_p\) in which both males and females had similar values (Table 4).

In validation assessment, the HMRAT_{10m} demonstrated that its measured aerobic profile presented a high correlation with the same indices measured in the MSRAT_{20m} and was an easily taught, reliable and reproducible task for the maximal aerobic capacity estimation.

### Discussion and conclusions

The purpose of the present study was to develop a modified field test easy in use in order to estimate aerobic performance. The confirmation and justification of the HMRAT_{10m} use as a new test was based both on the assessment of test-retest coefficient of reliability as well as on the determination of the validity of this test, assessing if there existed correlation coefficients between the same performance variables of HMRAT_{10m} and the already valid MSRAT_{20m}. The aerobic parameters (ending level, \(S_{\text{max}}\) and \(V_{\text{O}2\max}\)) as measured during both HMRAT_{10m} in PE students, presented high test-retest reliability. Thus, the present study supports the fact that the HMRAT_{10m} is an easily taught, reliable and reproducible field test easy in use in order to estimate aerobic capacity.
during the already valid MSRAT_{20m}, confirming that the proposed version, compared to MSRAT_{20m} is a valid field test for the prediction of aerobic performance. Furthermore, the mean HR_p of 196±6.2 b/min as a parameter recorded for the maximal nature evaluation of the new version is in accordance with a similar design MSRAT_{20m} validation study held in adolescents (Murray et al., 1993) confirming the participants maximal effort during the HMRAT_{10m}. Additionally the absence of significant differences at the finishing point HR_p between HMRAT_{10m} and MSRAT_{20m} lead to the strong evidence that both tests were characterized by a similar fatigue profile.

The comparisons between HMRAT_{10m} and MSRAT_{20m} concerning the ending level, the S_{max} and the VO_{2max} showed a statistically significant difference of both tests performance parameters, while the finishing point HR_p did not show significant differences in adolescents in both tests (Table 5). The adolescents’ aerobic performance of HMRAT_{10m} in comparison to that of MSRAT_{20m} was 31.7% better at the ending level, 9% higher at the finishing point S_{max} and 11.3% greater in VO_{2max} which could be the most important evidence of this study (Table 5). Considering that the HR_p at the finishing time was almost similar in both tests, interpreting the maximal participants’ effort, we can assume that the HMRAT_{10m} exhibits a better maximal aerobic performance than MSRAT_{20m}.

<table>
<thead>
<tr>
<th></th>
<th>HMRAT_{10m}</th>
<th>MSRAT_{20m}</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (km/h)</td>
<td>6.3±2.3*</td>
<td>4.3±1.8</td>
<td>31.7</td>
</tr>
<tr>
<td>S_{max} (km/h)</td>
<td>11.1±1.1*</td>
<td>10.1±0.9</td>
<td>9</td>
</tr>
<tr>
<td>VO_{2max} (ml/kg · min)</td>
<td>46±6.2*</td>
<td>40.8±4.9</td>
<td>11.3</td>
</tr>
<tr>
<td>HR_p (b/min)</td>
<td>196±6.2</td>
<td>194±9.7</td>
<td>1</td>
</tr>
</tbody>
</table>

* p<0.01

From a practical point of view, the primary source of this variance in performance during the HMRAT_{10m} in relation to the MSRAT_{20m} may be interpreted as a result of the participants’ better biomechanical efficiency during the HMRAT_{10m} which is associated with the continuous and not intermittent characteristic of running at the modified version presented. The higher S_{max} yielded from the HMRAT_{10m}, adolescents’ performance in relation to the MSRAT_{20m} S_{max} resulted in greater VO_{2max} values possibly due to the fact that four angles of the proposed test are 150° which means that the running directions are almost circular. For this reason, the HMRAT_{10m} seems to be easier in higher maximum speed acquisition which results in greater VO_{2max} values in contrast to the intermittent and changing running directions of MSRAT_{20m}. The deceleration periods during the turn around and run back of the MSRAT_{20m} possibly affect a decrease in the stride length and running speed of the participants, resulting in a higher anaerobic contribution, earlier fatigue and earlier onset of test termination or ending the MSRAT_{20m}. In the same way a recent study presented a modification of MSRAT_{20m} for the prediction of VO_{2max} in adults named the Squared Endurance Test 20m (Flouris et al., 2003). Similarly with the present study, the Squared Endurance Test 20m (SET_{20m}) validity analysis, based on maximal aerobic performance estimation from the MSRAT_{20m} protocol, presented a high correlation of 0.89 (p<0.001) for the VO_{2max} in both tests. The above version gives higher S_{max} at the finishing point and greater ending level than the MSRAT_{20m}, but not as high as S_{max} and the ending level measured values of HMRAT_{10m}. Furthermore, the comparisons between the participants’ gender of this study are in accordance with other studies (Murray et al., 1993; Armstrong et al., 1998) confirming that in all physiological and performance variables, males appeared to have a better aerobic profile in both tests than females and consequently male adolescents had greater aerobic performance than females in HMRAT_{10m}.

In conclusion, the Hexagon Multi-Level Running Test for the aerobic performance estimation was not designed and developed to replace the Multistage Shuttle-Run Aerobic test. This modified version tries to cover kinematically the gap between the shuttle intermittent nature of MSRAT_{20m} with the circular running nature of endurance field tests which are carried out on a track with a steady state or progressively increasing running speed. The predominance of HMRAT_{10m} reliability correlations in relation to its high validity coefficients in comparison to MSRAT_{20m} could propose this test as an alternative task for the prediction of VO_{2max}. Further research evaluating the validity coefficients of aerobic performance of HMRAT_{10m} in the form of maximum oxygen uptake (VO_{2max}) in research laboratories settings could define the HMRAT_{10m} as a new, valid and well accepted field test with its own equations for the aerobic performance estimation in a variety of ages, population and range of sports.
References


Submitted: September 4, 2006
Accepted: September 26, 2007

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POUZDANOST I VALJANOST MODIFICIRANOGA TERENSKOG TESTA ZA PROCJENU AEROBNE SPOSOBNOSTI

Sažetak

Uvod

Tijekom posljednjih tri desetljeća pojavio se po-većan interes za mjerenje aerobnih sposobnosti na razini populacije. Do danas su se te fiziološke karakteristike pretežno određivale primjenom laboratorijskih mjerenja, poput submaksimalnih ili maksimalnih testova na bicikl-ergometru ili pokretnom sacu. Nasuprot tome, terensko testiranje je jedino rješenje u kojem znanstvenik može učinkovito simulirati sportske situacije. Cilj je ovog istraživanja bio ocijeniti pouzdanost i valjanost modificirane verzije višestupanjskog aerobnog testa izmjeničnog trčanja na 20 metara (Multistage Shuttle-Run Aerobic Test 20m - MSRAT20m).

Metode

Predložena verzija je šesterokut sa svakom stranicom duljine od 10 metara. Test je nazvan šesterokutni višerazinski aerobni test trčanja na 10 metara (Hexagon Multilevel Running Aerobic Test 10m - HMRAT10m). Da bi se opravdalo razvijanje modificiranog terenskog testa, ocijenjeni su HRMRAT10m, test-retest koeficijent pouzdanosti i valjanosti parametara mjerenih testom HMRAT10m s istim parametrima MSRAT20m testa. U oba testa (MSRAT20m i HMRAT10m) je korišten MSRAT20m protokol izmjerena završna razina, maksimalna brzina i frekvencija srca u završnoj točki, a procijenjen je i maksimalni primitak kisika (VO2max) (Ramsbottom, Brewer, Williams, 1988).

U evaluaciji pouzdanosti HMRAT10m, predložena verzija testa primijenjena je na uzorku od 18 studenata kineziologije (10 mladića i 8 djevojaka) u dobi od 20.8±0,9 godina. Test je izveden dva puta, s intervalom od 48 sati između dva izvođenja. Završna razina HRMRAT10m, dala je izvrsnu IC korelaciju (0,99) u oba izvođenja (8,1 vs 8,3). Slično tome, visoka IC korelacija opažena je između dva izvođenja tijekom oba HRMRAT10m testa pri maksimalnoj brzini u završnoj točki (0,99), što odgovara brzini koju su studenti postigli na posljednjem uspješno izvedenom razini testa (12 vs 12,1km/h). Uz to, VO2max (47,2±9,1 vs 47,6±9,3 ml/kg/min), procijenjen na temelju tablića MSRAT20m, protokola, u oba je HRMRAT10m testa pokazano koeficijent pouzdanosti od 0,99. Za razliku od toga, za vršnu je frekvenciju srca u izvođenju HRMRAT10m testa, koeficijent pouzdanosti bio je 0,77, dok su se srednje vrijednosti vršne frekvencije srca ispitanika kretale u rasponu od 191±8.1b/min u prvom HRMRAT10m testu, do 194±4 b/min u drugom HRMRAT10m testu.

Osim ocjene pouzdanosti testa HRMRAT10m, bilo je nužno dobiti koeficijente korelacije između varijabli modificirane verzije i varijabli mjerenih već valjanim testom. Za evaluaciju valjanosti HRMRAT10m parametri ovog testa uspoređeni su s istim parametrima MSRAT20m testa kod 62 trenirana adolescenta (39 mladića i 23 djevojke), u dobi od 13,7±0,7 godina.

Rezultati

U ocjeni valjanosti mjerenih parametara predstavljene modificirane verzije na razini odustajanja ili na završnoj razini testa, maksimalna brzina u završnoj točki i VO2max u oba HRMRAT10m i MSRAT20m testa pokazali su koeficijente korelacije do razine od r=0,86, (p<0,01), dok je fiziološka varijabla frekvencija srca u završnoj točki u oba testa pokazala nisku korelaciju (r=0,33, p<0,01). Parametri aerobne sposobnosti adolescenata u HMRAT10m testu, u odnosu na parametre u MSRAT20m testu, bili su 31,7% bolji na završnoj razini, 9% viši kod maksimalne brzine u završnoj točci i 11,3% veći u VO2max što je možda i najjači dokaz ovog istraživanja. Uzimajući u obzir da je vršna frekvencija srca ispitanika u završnoj točki, kao pokazatelj maksimalnog napora ispitanika, bila prilično slična u oba testa, možemo pretpostaviti da HRMRAT10m pokazuje bolje maksimalne aerobne sposobnosti od MSRAT20m.

Normaliziranjem rezultata prema spolu, dobili smo podatke da su adolescen ti muškog spola pokazali bolje rezultate tijekom HRMRAT10m od djevojaka, a u odnosu na MSRAT20m, izuzevši vršnu frekvenciju srca u završnoj točki, u kojoj su i mladići i djevojke imali slične vrijednosti. Stoviše, usporedbе ispitanika prema spolu u ovom istraživanju potvrđuju da su u svim mjerenim varijablama mladići imali bolji aerobni profil od djevojaka u oba testa te su, posljednjo, adolescenti muškog spola imali bolje aerobne rezultate od djevojaka u testu HRMRAT10m.

Zaključci

U zaključku, HRMRAT10m test za procjenu aerobne sposobnosti dizajniran je da kinematički pre-nosti jau između intermitentne naizmjenične oso-ebne sposobnosti adolescenata testa i kružne trkače osobine terenskog testa izdržljivosti koji se izvode na stazi, sa stalnom ili progresivno rastućom brzinom trča-čnja. Prevladavanje korelacija pouzdanosti HRMA-Rezultati

1. HRMRAT10m testa u odnosu na njegove visoke koeficijente korelacije između istih parametara s MSRAT20m testom, moglo bi ovaj test ponuditi kao alternativni oblik procjene VO2max. Daljnja istraživanja, koja bi u uvjetima istraživačkih laboratorija evaluirala koeficijente valjanosti aerobnih rezultata HRMRAT10m testa u vidu VO2max, mogla bi HRMRAT10m test definirati kao novi, valjan i dobro prihvaćen terenski test, s vlastitim jednadžbama za procjenu aerobne sposobnosti za različite dobrine, populacije i različite sportove.