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SPORT AND PHYSICAL EDUCATION

UNIVERSITY OF WALES INSTITUTE, CARDIFF
THE RELATIONSHIP OF REPEATED AGILITY TO STRENGTH, POWER AND REPEATED SPRINTS
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Abstract

Agility is one of a number of crucial factors which influence sporting performance. The performance of agility and particularly repeated agility however has received limited research in comparison with other physiological determinants of performance such as repeated sprint ability, power or strength. The purpose of the present study was to determine if repeated sprint ability, power or strength significantly affect repeated agility performance. Twelve male, university standard rugby players performed, in a randomised order, a repeated sprint test, a 1 repetition maximum half squat test, a power test and a repeated agility test. Mean values for the repeated sprint test, the power test and the peak 1 repetition maximum half squat were correlated against mean values for the repeated agility test. The mean reactive change of direction presented no significant correlation with any of the other performance variables (-0.406 < r < 0.418). Mean total agility time found to correlate with mean reactive strength index, (r = -0.623, P = 0.03), mean 30m sprint time (r = 0.638, P = 0.026) and mean total sprint time (r = 0.595, P = 0.041). Mean initial acceleration of the agility protocol also showed correlations with mean reactive strength index (r = -0.602, P = 0.038), mean 30m sprint time (r = 0.688, P = 0.013) and mean total sprint time (r = 0.658, P = 0.02). The low correlations of the mean reactive change of direction in particular suggest that repeated agility is a distinct physiological variable which needs significant concentration within training if players are to improve.
CHAPTER I

INTRODUCTION
1.0 Introduction

The physiology of sports performance is an area which has a vast background of research. Indeed, an extensive amount of studies have been performed assessing the strength, power and sprinting capabilities of various groups of athletes (Dawson et al., 1993; Fitzsimmons et al., 1993; Harrison et al., 2004; Kotzamanidis et al., 2005; Stone et al., 2006; Holtermann et al., 2007b). It is generally accepted that these factors have a large bearing on the success of athletes, particularly within games sports. It is also understood that knowledge of an athlete’s ability to perform these various components can aid their training by allowing sport specific goals for improvement. Agility, however, has a limited research background with few studies concentrating on this area (Young et al., 2002; Brown and Vescovi 2003; Craig, 2004; Farrow et al., 2005; Sheppard and Young, 2006 and Young and Farrow, 2006). There are also a number of limiting factors in existing studies such as the definition of agility, assessment methods and the terms speed and agility have been used interchangeably. Additionally, the area of repeated agility activity - as an athlete may expect to undertake during a game activity - appears to have been particularly neglected.

Games activities are characterised by repeated bouts of varying intensity activities (Bishop and Edge, 2006; Deutsch et al., 2007; Duthie et al., 2003; Gamble, 2004; Spencer et al., 2004). Many studies have been performed to examine the movement characteristics of games athletes and there seems a general consensus that work to rest ratios are, on average, between 1:4 to 1:8 with slight variations between sports (Deutsch et al., 2007; Fitzsimons et al., 1993; Spencer et al., 2004). Dawson et al. (1993) states that athletic performance should be assessed by measuring the
athletes’ ability to regularly reproduce sport specific actions at the highest intensity that they would expect to find in a game, rather than a one off maximal effort. Studies into the movement patterns of games sports have highlighted components such as sprints and repeated sprints as essential actions for performance, whilst strength and power capabilities were noted as integral to contact sports.

Stone et al. (2006) describes strength as the ability to produce force and as such is vital to games players. Cronin et al. (2007) concur, stating that strength is essential for sporting performance and resultanty, many athletes include resistance training to improve the force capability of their muscles. Cronin et al. (2007) also found that enhancements of strength via resistance training resulted in positive improvements of sprint performance. Kotzamanidis et al. (2005) supported this argument, determining that combined high resistance training and sprint training in the same sessions were most beneficial. Many tests have also indicated that strength has links with power and the rate of force development (Mirkov et al., 2004; Andersen and Aagaard, 2006; Holtermann et al., 2007a; and Holtermann et al., 2007b). It therefore appears that strength is vital for not just as a single component within sporting performance but for the impact it has upon other crucial factors within sport (Tsitskaris et al., 2003).

Due to the intermittent nature of high intensity activity observed during games sports, a number of studies have been performed into the repeated sprint ability of athletes. Spencer et al. (2005) contested that the ability to perform repeated sprint bouts with minimal recovery between, is an important aspect of team sports. As such, studies, such as Dawson et al. (1993), have focused upon repeated sprint
ability, finding that repeated sprint ability was closely correlated to performance measures of anaerobic power and work capacity. In addition, a number of studies have been performed to assess the validity of repeated sprint test protocols and their use for assessing sport specific fitness. Wragg et al. (2000) performed one such study by assessing a sport specific field test against an anaerobic laboratory test in order to find a sport specific measure of repeated sprint ability. In addition, studies such as that performed by Bishop and Edge (2006) into the determinants of repeated sprint performance have provided insight into the physiological factors that underpin repeated sprints.

Power is an important aspect of any games athlete as it gives them the ability to win contact situations, contest for possession and can give an added dimension to an athlete’s performance. Saez Saez de Villarreal (2007) stated that muscle power and explosiveness had been shown to be a major factor in successful sports performance. As such, studies such as Andersen and Aagaard (2006) have focused on athletes’ power and the ‘explosiveness’ of their muscle contraction. Andersen and Aagaard’s study used the term ‘rate of force development’ to explain the explosive muscle strength and the muscle’s ability to rapidly produce muscular force. This term has been the basis of a number of studies assessing the ability of an athlete to produce muscular force quickly; which by definition is a power movement (Mirkov et al., 2004; Holtermann et al., 2007a and Holtermann et al., 2007b).

Another crucial term used throughout the literature is the stretch-shortening cycle, which is the eccentric to concentric contractions of the leg extensor muscles (Hennessy and Kilty, 2001). Hennessy and Kilty (2001) explain that the stretch-shortening cycle results in a more powerful concentric contraction compared with
concentric contraction performed without prior eccentric movement. Both the stretch-shortening cycle and the rate of force development characteristics of athletes’ muscles have been widely researched and have also been linked with agility, strength and sprinting performance (Hennessy and Kilty, 2001; Young et al., 2001; Young et al., 2002; Brown and Vescovi, 2003; Harrison et al., 2004; Mirkov et al., 2004; Andersen and Aagaard, 2006).

Agility is an important factor within sports performance, which can often be overlooked and has not yet been extensively researched (Young and Farrow, 2006). The ability to change the body’s position quickly and effectively in a response to a stimulus is crucial in almost all sports (Craig, 2004). Current studies into agility have been flawed in many ways such as the athlete’s ability to predict the next move (Craig, 2004) or the combination of sprinting and agility activities (Wragg et al., 2000). Sheppard and Young (2006) contested that agility is a rapid whole body action with a change in direction and velocity in response to an external stimulus. Investigations should therefore take all these factors into consideration when designing test protocols. In addition, Sheppard and Young (2006) suggested that previous studies may have been flawed due to the number of different theories and definitions of agility. It has also been contested that due to the complexity of some theories, confusion about their true meaning could have caused test protocols to have inherent confusion and flaws. As a result, Sheppard and Young (2006) concluded that a new agility protocol should be designed to account for physical performance measures and perceptual factors.
With the abundance of studies investigating the other physiological components which influence sporting performance, it appears that agility has been somewhat neglected. Research into this area could provide vital information so coaches can be advised if there is a gap within training, which may affect games athletes’ performance. Therefore the purpose of this study was to a) correlate performance measures of repeated agility with measures of repeated sprint ability, power and strength and b) assess if repeated sprint ability, power and strength significantly affect agility performance.

It is hypothesised that power will display the highest correlations with repeated agility whereas repeated sprints will produce the lowest.
CHAPTER III

METHODOLOGY
3.0 Method

3.1 Subjects
Twelve male, university standard rugby players (age 20.5 ± 1.6yr, height 1.86m ± 0.06m, body mass 92.5 ± 9.1kg) volunteered to participate in the current study. All subjects had been using resistance training, plyometrics and sprint training for at least 2 years prior to the experiment. All participants were free from injury and illness and had completed the informed consent approved by the University of Wales Institute, Cardiff Ethics Committee. The subjects were informed of the procedures, purpose and possible risks of the experiment prior to commencement.

3.2 Experimental Protocol
The study was conducted by using repeated sprints, a 1RM half squat, a 5 bounce jump protocol and a repeated agility test. The tests were randomised for each subject to avoid systematic error. Data collection was split into four sessions over 2 weeks, allowing each subject to perform all of the tests once. Each participant undertook a familiarisation session the week prior to data collection so that they were comfortable with each test and no learning effect would interfere with the data collection. Uniform encouragement was given to all participants throughout the study. Prior to each testing session, the participants performed their own warm up and were fully prepared. The participants were advised not to exercise or drink alcohol within 24hrs of the testing session. In addition, eating on the day of testing was recommended, however not within 2 hours of the experiment. Hydration was also encouraged prior to and throughout testing.
3.3 Repeated Sprint Protocol

The repeated sprint protocol was adapted from research by Fitzsimmons et al. (1993) and Spencer et al. (2004) in accordance with research by Deutsch et al. (2007) and Duthie et al. (2003) to add specificity for the participants. Repeated sprint ability evaluation comprised of 10 x 40 metre sprints commencing every 30 seconds. The 40m sprints were timed using electronic timing gates (Fusion Sport, Brisbane, Australia). The timing gates were placed at 10 and 40m on an indoor track in order to standardise conditions for each participant and prevent environmental conditions, such as adverse weather, affecting the results. The participants began each sprint with a verbal command from the test administrator. On the command, the participant would sprint 40m as fast as possible. The participant was required to make his way back to the starting point within 30 seconds of the commencement of the previous test. As the participant was required to jog or walk to recover to the starting position, their recovery was active, simulating the active recovery within a game situation. The participant was required to complete 10 repetitions of the 40 metre sprints. The chosen performance measures of repeated sprint ability were the mean 10m sprint time, the mean sprint time between 10m and 40m and the mean total sprint time. Figure 2 shows a diagram of the repeated sprint protocol.
Figure 2. Diagram of Repeated Sprint Protocol. a, start; b, first timing gates (0m); c, second timing gates (10m); d, third timing gates (40m); dashed line, recovery jog/walk to start position; solid arrow, direction of sprint.

3.4 1RM Half Squat Protocol

Each participant was familiar with the half squat technique from prior training. The bar was supported upon the shoulders and firmly grasped with both hands for balance. The participants kept a straight back position and bent their knees until they reached the 90° limit. Once the 90° position was reached, the participant raised himself to the upright position with the legs completely extended. To test the participants’ one repetition maximum, each participant started at a load they knew they were capable of and increased the load until they were unable to complete the movement unaided. For safety purposes, there were 3 ‘spotters’ for each squat, one on either side of the bar and one behind the participant to aid the completion of the movement if necessary.
3.5 5 Bounce Jump Protocol

To test the participants’ power, a 5 bounce jump routine using a jump matt (Fusion Sport, Brisbane, Australia) was used. To begin the test, the participants stood on the jump matt and were instructed to perform a countermovement jump, followed by 4 consecutive vertical jumps. The participants were instructed to jump as quickly and as high as possible. The jump matt automatically calculated jump height, contact time, flight time, impulse, power and the reactive strength index of the jump.

3.6 Repeated Agility Protocol

As there has been little research into the area of reactive agility, a new protocol was devised. Following personal correspondence with Dr Jon Oliver who recently performed reliability testing on an agility protocol and from piloting a number of tests, the following protocol was devised. The protocol takes account of the reactive nature of agility, change of direction speed and does not confuse agility with speed which is a limitation of many previous studies into agility. The agility protocol begins with a 5m acceleration to a timing gate (Fusion Sport, Brisbane, Australia), initiated by a solid green light emitted by the timing gate. The timing gate emits a flashing light once the test administrator triggers it and has a 1-5 second delay before the solid green light is emitted. This therefore simulates a reactional start as a player may make in a game, as they cannot anticipate the starting trigger and must react to the stimulus. Once the timing gate has been reached it triggers one of two timing gates positioned 3 metres either side of the first gate and 4 metres forward. The gate which is triggered will flash instantly, indicating to the participant to cut to that gate. Cutting back to a central gate, 3 metres to the centre and 4 metres forward from the second set of gates completes the test. Participants complete 10 repetitions of this
activity and must run a total of 15 metres each repetition. From piloting and taking into account the 4:1 ratio of work to rest, participants are given 20 seconds to complete the test and recover to the starting position for the next repetition. The chosen performance measures of repeated agility were the mean time to the first timing gate, the mean time to the second timing gate and the mean total agility time. In order to isolate the specific agility cutting action, the time between the first gate and the second gate was also calculated and used as a measure of agility. Figure 3 shows a diagram of the repeated agility protocol.

![Diagram of the Repeated Agility Protocol](image)

**Figure 3.** Diagram of the Repeated Agility Protocol. a, start; b, first timing gates; c, second timing gates; d, final timing gates; dashed line, recovery jog/walk to start position; solid arrow, direction of sprint.
3.7 Statistical Analysis

A Pearson’s two-tailed correlation was used to compare measures of repeated agility against squats, repeated sprints and power. The agility measures were correlated against 1RM squat, the mean 10m sprint time, the mean sprint time between 10m and 40m and the mean total sprint time as well as all six measures of power calculated by the force matt. The levels of significance were set to $P \leq 0.05$. The Statistical Package for Social Sciences 12.0 (SPSS, Chicago, Illinois) was used to analyse the data. All tables and graphs were composed using Microsoft Excel (Microsoft Corporation, USA).
CHAPTER IV

RESULTS
4.0 Results

Table 4.1 shows the mean split times of the agility protocol for each of the participants. Correlations performed on the data showed that the mean first split and total agility time significantly correlated with the mean reactive strength index \((r = -0.623, P = 0.03)\) and \((r = -0.602, P = 0.038)\) respectively. Figure 4 demonstrates the negative correlation between the mean reactive strength index and the mean time to the first agility timing gate. The correlation performed between reactive strength index and the mean second split for agility found a high but non-significant correlation \((r = -0.556, P = 0.06)\). The statistical analysis of the remaining performance variables of power found no correlation to the mean agility data.

Table 1. The Mean Split Times of the Agility Protocol for Each Player.

<table>
<thead>
<tr>
<th>PLAYER 1</th>
<th>Agility Split 1 (s)</th>
<th>Agility Split 2 (s)</th>
<th>Agility Split 1-2 (s)</th>
<th>Agility Total (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAYER 1</td>
<td>2.11</td>
<td>3.74</td>
<td>1.63</td>
<td>4.97</td>
</tr>
<tr>
<td>PLAYER 2</td>
<td>1.88</td>
<td>3.3</td>
<td>1.42</td>
<td>4.61</td>
</tr>
<tr>
<td>PLAYER 3</td>
<td>1.91</td>
<td>3.48</td>
<td>1.58</td>
<td>4.65</td>
</tr>
<tr>
<td>PLAYER 4</td>
<td>1.85</td>
<td>3.35</td>
<td>1.5</td>
<td>4.54</td>
</tr>
<tr>
<td>PLAYER 5</td>
<td>2.02</td>
<td>3.59</td>
<td>1.57</td>
<td>4.74</td>
</tr>
<tr>
<td>PLAYER 6</td>
<td>1.79</td>
<td>3.32</td>
<td>1.53</td>
<td>4.5</td>
</tr>
<tr>
<td>PLAYER 7</td>
<td>1.73</td>
<td>3.19</td>
<td>1.46</td>
<td>4.33</td>
</tr>
<tr>
<td>PLAYER 8</td>
<td>1.93</td>
<td>3.47</td>
<td>1.53</td>
<td>4.81</td>
</tr>
<tr>
<td>PLAYER 9</td>
<td>1.77</td>
<td>3.37</td>
<td>1.6</td>
<td>4.54</td>
</tr>
<tr>
<td>PLAYER 10</td>
<td>1.66</td>
<td>3</td>
<td>1.34</td>
<td>4.18</td>
</tr>
<tr>
<td>PLAYER 11</td>
<td>1.65</td>
<td>2.96</td>
<td>1.31</td>
<td>4.09</td>
</tr>
<tr>
<td>PLAYER 12</td>
<td>2.03</td>
<td>3.76</td>
<td>1.73</td>
<td>5.05</td>
</tr>
</tbody>
</table>
Significant correlations were found between the mean time between 10m and 40m during the sprint and the time to the first agility timing gate ($r = 0.688$, $P = 0.013$) as well as the mean time to the second agility timing gate ($r = 0.600$, $P = 0.039$) and the mean total time for the agility protocol ($r = 0.638$, $P = 0.026$). Figure 4.2 shows the positive relationship between the mean 10m-40m sprint time and the mean total agility time.
When analysed, the mean total sprint time was found to significantly correlate with the mean time to the first agility timing gate \((r = 0.658, P = 0.02)\) and the mean total time for the agility protocol \((r = 0.595, P = 0.041)\). High but non-significant correlations were also found between the mean total sprint time and the time to the second agility timing gate \((r = 0.565, P = 0.056)\).

The data from the 1RM half squat displayed high but non-significant correlations with all three agility variables. The highest correlation was with the mean time to the first agility timing gate \((r = -0.573, P = 0.051)\), then the mean total time \((r = -0.524, P = 0.080)\) and finally the mean time to the second timing gate \((r = -0.523, P = 0.081)\).
Additionally, high but non-significant correlations were found between the mean 10m time during the sprint protocol and the mean time to the first agility timing gate ($r = 0.513, P = 0.088$). Table 2 shows the repeated sprint and squat data for each of the players.

Table 2. Mean Repeated Sprint Data and Squat Data for Each Player

<table>
<thead>
<tr>
<th></th>
<th>RS 10m (s)</th>
<th>RS 10-40 (s)</th>
<th>RS total (s)</th>
<th>Squats (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAYER 1</td>
<td>2.41</td>
<td>5.33</td>
<td>7.74</td>
<td>222.5</td>
</tr>
<tr>
<td>PLAYER 2</td>
<td>2.08</td>
<td>4.39</td>
<td>6.46</td>
<td>215</td>
</tr>
<tr>
<td>PLAYER 3</td>
<td>1.95</td>
<td>4.04</td>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>PLAYER 4</td>
<td>1.99</td>
<td>4.31</td>
<td>6.3</td>
<td>220</td>
</tr>
<tr>
<td>PLAYER 5</td>
<td>2.16</td>
<td>4.52</td>
<td>6.68</td>
<td>177.5</td>
</tr>
<tr>
<td>PLAYER 6</td>
<td>1.96</td>
<td>4.12</td>
<td>6.07</td>
<td>215</td>
</tr>
<tr>
<td>PLAYER 7</td>
<td>2.24</td>
<td>4.25</td>
<td>6.49</td>
<td>237.5</td>
</tr>
<tr>
<td>PLAYER 8</td>
<td>2.19</td>
<td>4.8</td>
<td>6.99</td>
<td>192.5</td>
</tr>
<tr>
<td>PLAYER 9</td>
<td>2.04</td>
<td>4.42</td>
<td>6.46</td>
<td>230</td>
</tr>
<tr>
<td>PLAYER 10</td>
<td>2.06</td>
<td>4.31</td>
<td>6.38</td>
<td>232.5</td>
</tr>
<tr>
<td>PLAYER 11</td>
<td>1.96</td>
<td>4.01</td>
<td>5.97</td>
<td>210</td>
</tr>
<tr>
<td>PLAYER 12</td>
<td>2.05</td>
<td>4.41</td>
<td>6.47</td>
<td>192.5</td>
</tr>
</tbody>
</table>

The analysis performed on the specific agility cutting movement between gate 1 and gate 2 of the agility protocol showed low and non-significant correlations throughout ($-0.406 < r < 0.418$), with a low average correlation ($r = 0.300$) and significance ($P = 0.37$).


Farrow, D. Young, W. and Bruce, L. (2005) The development of a test of reactive agility for netball: a new methodology. Journal of Science and Medicine in Sport, 8; 1, 52-60


APPENDIX A
Physical Activity Readiness Questionnaire (PAR-Q)

Please circle the answers to the following questions:

1. Has your doctor ever said you have heart condition and that you should only do physical activity recommended by a doctor?  Yes / No

2. Do you feel pains in the chest when you do physical activity?  Yes / No

3. In the past month have you had chest pain when you were not doing physical activity?  Yes / No

4. Do you lose your balance because of dizziness or do you ever lose consciousness?  Yes / No

5. Do you have a bone or joint problem that could be made worse by physical activity, jumping actions or cutting actions?  Yes / No

6. Is your doctor currently prescribing drugs for blood pressure or a heart condition?  Yes / No

7. Do you know of any other reason why you should not do physical activity?  Yes / No

If you have answered yes to any of these questions, please add details below. Similarly, if there are any situations which will prevent you from exercising write them here

Signed………………………………………………….

Date…………………………………………………….
APPENDIX B
Informed Consent

I am an undergraduate student at the University of Wales Cardiff undertaking research for my dissertation in the area of physiology. The title of my study is “Physiological Correlations of Repeat Agility Activity”. The study is designed to test anaerobic physiological components against repeated agility. This may interest you as it has applications within a number of games sports, such as rugby union.

As a participant, you will be required to take part in a repeated sprint test, repeated agility test, a vertical jump test and a 1RM squat test. These tests are designed to test your anaerobic system and as such you may become fatigued. If you have any concerns, the study administrator will answer any questions you have prior to and during testing.

Any personal data collected for the purposes of testing will be kept confidential and the study administrators are the only people with access to this data.

Participant:

I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

I understand the risk involved, that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I understand that relevant sections of any of research notes and data collected during the study may be looked at by the study administrators. I give permission for these individuals to have access to my records.

I agree to take part in the study of Mr D. Fulling.

Signature of Participant : …………………………………………………………

Date : …………………………….