The Relationship Between Strength, Speed, Flexibility, Agility, and Anaerobic Power in Elite Athletes

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ABSTRACT
The aim of this study was to determine whether there is a relationship between strength, speed, flexibility, agility, and anaerobic power in elite athletes. In various sport branches 29 active male athletes participated in this study with an average age of 21.14±1.98 years who without any health problems. Back and leg strength were measured by dynamometer (Takei), speed was measured by 20 meters test, agility was measured by T test, flexibility was measured by sit and reach test, vertical jump sit-reach test by Jumpmeter (Takei) anaerobic power was calculated by the Lewis formula. The data were analyzed in SPSS 22.0 for Windows package program. Bivariate - Pearson Correlation test was used to determine the relationship between strength, speed, flexibility, agility, and anaerobic power. The results were interpreted as .05 significance level. We were found positive and significant relationships between the back and leg force, between anaerobic power and vertical jumping, between anaerobic power and back force, between anaerobic power and leg strength, and between flexibility and vertical jumping. And also, there was a negative and significant relationship between flexibility and agility, between speed and vertical jump, and between agility and vertical jump. In this study, it was concluded that strength, vertical jump and anaerobic power was related both each other and the other. For this reason, we recommend that the trainings cover all motoric characteristics.

1. Introduction
The basic motoric features grouped as strength, speed, endurance, flexibility (mobility) and skill (coordination) are "the features, one or several of which are used to make a movement happen, that can be improved and vary from one person to another" (1). Strength is the tension that occurs during muscle contraction (2) and it is the contraction or resistance of muscles that are exposed to any resistance for a certain period of time (3). Strength is one of the motoric features that play a role in the formation of sportive skills (1). Speed is the ability of an athlete to move from one place to another in the fastest way or to perform the movement as fast as possible (4). Durability is the ability of the organism to resist the load which affects it (5). It is examined in different ways, most commonly as aerobic and anaerobic endurance. Aerobic endurance, also known as aerobic power, is the performance capacity in long-term exercises (6). Anaerobic endurance, on the other hand, is to maintain fast, rhythmic, dynamic, and maximal exercises at the anaerobic level (4). According to Agirbas (2019), sportive endurance is the capacity to perform skill-demanding movements for a longer duration or with more repetitions in aerobic or anaerobic processes (1). Flexibility is the ability to perform the
movements of different body parts and the muscular system with maximum conformity (7). It is the ability to deliberately make a movement at a maximum wide angle (8). Coordination is to work cooperatively to achieve a coherent result in biological systems (TDK). Skill is the sportive coordination. According to Sevim (2010), the skill is that the skeletal muscles and the central nervous system work together in constant interaction in a targeted way (4). It is the ability to increase power in a short time, to comprehend the movement, to react in a rapid manner in accordance with the target in different events (7). Agility is the ability to quickly change direction while maintaining balance without loss of speed (9). Agility consists of two main components: decision-making mechanisms and speed of changing direction (10).

When the literature is examined, it is seen that two motoric features have been generally examined in the researches on the relationship of motoric features with each other. In this study, the relationship among strength, speed, anaerobic endurance, flexibility and agility were examined in athletes.

2. Method
2.1. Participants
A total of 29 healthy male volunteers, aged 18-25, who are active in football, volleyball, basketball, handball, athletics, wrestling, boxing and karate branches participated in the study.

2.2. Measurement of Motoric Properties
Back and leg strength measurements were determined by Takei (Japanese) brand dynamometer, speed measurement by 20 meters speed test, flexibility measurement by sit-access test, and agility measurement by T test. The Lewis formula was used to determine anaerobic power (11). Vertical jump distance in this formula was measured by Takei brand jump meter. Anaerobic power calculation with Lewis formula is as: Anaerobic Power (Watts) = \sqrt{4.9 \times \text{Body Weight (kg)} \times \sqrt{\text{Vertical Jump Score (m)}} \times 9.81 / \text{time} (12).

2.3. Statistical Analysis
The obtained data were analysed via SPSS 22.0 for Windows package program. After calculating the mean and standard deviations of the male athletes, normality analyses of the distribution were performed. As a result of these analyses, the distribution was found to be normal. Therefore, "Bivarity - Pearson Correlation” test was used to determine the relationship among the values of athletes. Results were interpreted at the level of significance of .05.

3. Results

Table 1. The relationship of male athletes’ motoric characteristics (Pearson correlation)

<table>
<thead>
<tr>
<th></th>
<th>Flexibility</th>
<th>Back Strength</th>
<th>Leg Strength</th>
<th>Speed</th>
<th>Agility</th>
<th>Vertical Jump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back Strength</td>
<td>.195</td>
<td>(.311)</td>
<td>.139(.47)</td>
<td>-.105</td>
<td>-.408</td>
<td>(.646)</td>
</tr>
<tr>
<td>Leg Strength</td>
<td>(.308)</td>
<td>(.798)</td>
<td>(.454)</td>
<td>.089</td>
<td>.286</td>
<td>(.941)</td>
</tr>
<tr>
<td>Speed</td>
<td>(.586)</td>
<td>(.145)</td>
<td>(.894)</td>
<td>.200</td>
<td>.133</td>
<td>(.371)</td>
</tr>
<tr>
<td>Agility</td>
<td>(.028)</td>
<td>(.026)</td>
<td>(.089)</td>
<td>.328</td>
<td>.371</td>
<td>(.375)</td>
</tr>
<tr>
<td>Vertical Jump</td>
<td>.474</td>
<td>(.286)</td>
<td>(.299)</td>
<td>.083</td>
<td>.047</td>
<td>(.083)</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>(.009)</td>
<td>(.132)</td>
<td>(.491)</td>
<td>.045</td>
<td>.045</td>
<td>(.045)</td>
</tr>
<tr>
<td>Power</td>
<td>.255</td>
<td>(.528)</td>
<td>(.458)</td>
<td>.036</td>
<td>.185</td>
<td>(.743)</td>
</tr>
</tbody>
</table>

*\(p<.05\)

When Table 1 is examined, positive and significant relationships were found between back and leg strength,
The results of the study showed that there was a statistically significant and positive relationship between flexibility and vertical jump (Table 1). When the literature is examined, Aslan (2008), Con et al. (2012), and Taskin et al. (2015) reported a significant relationship between flexibility and vertical jump in their studies (15-17).

Another result of our study was that there was a statistically significant and negative relationship between speed and vertical jump (Table 1). Bayraktar (2013), in his study on elite boxers, showed that there was a negative and significant relationship between vertical jump and speed values (18), while Ek et al. (2007) in their study on football players (19), Korkmaz and Karahan (2012) on basketball players, and Taskin et al (2015) also reported that there was a significant relationship between vertical jump and speed (17, 20).

In the study, statistically significant and positive relationship was found between anaerobic power and back and leg strength (Table 1). A significant relationship was reported by Karatosun et al. (1998) between leg muscle mass and anaerobic power, by Harmanci et al. (2007) between leg strength and anaerobic power, by Simsek et al. (2007) between strength and dive in female volleyball players, by Ozkan and Sarol (2008) between leg volume and mass and anaerobic power in mountaineers, by Aslan et al. (2011) between anaerobic power and back force, and by Taskin et al. (2015) between vertical jump and 30-second push-up test, while Zorba et al. (2010) stated that leg volume and leg masses of wrestlers play an important role in anaerobic performance (17, 21-26).

As a result of the research, the motoric features that are determined to have no significant relationship are as follows: There was no significant relationship between flexibility and strength, speed and anaerobic power, strength and speed, agility and vertical jump, speed and agility, and also between anaerobic power and speed and agility. Similar results were observed in the studies examined in the literature. Taskin et al. (2015) reported that there was no significant relationship between flexibility and the 30-second push-up test, which is considered as a strength measurement (17). Acer (2016), in his study on 20 basketball players in Turkey Women's Basketball 2nd League,
reported that there was no significant relationship between flexibility and anaerobic power and speed values (30). Taskin et al. (2015) showed that there was no significant relationship between speed and 30-second push-up test, which was considered as a strength measurement (17), Young et al. (2001) examined the effects of flat sprint exercises on agility, and as a result of the study they found that flat sprint exercises did not improve the speed of changing direction (31), Ozdemir (2013) stated that there was no significant relationship between speed and agility in young players (32), while Gokhan, Aktas and Aysan (2015) reported no significant relationship between speed and flexibility values of amateur football players (33). In contrast to our results, Taskin et al. (2015) reported that there was a significant relationship between flexibility and vertical jump and speed and 30 seconds sit-up values (17).

When the research results are evaluated in general, positive and significant relationships were found between back and leg strength, between anaerobic power and vertical jump, between anaerobic power and back strength, between anaerobic power and leg strength, and between flexibility and vertical jump. Negative and significant relationships were found between flexibility and agility, between speed and vertical jump, and between agility and vertical jump. In this study, it was concluded that strength, vertical jump, and anaerobic power depending on strength were significantly related to each other or other motoric properties.

Considering the relationship of motoric properties with each other, we recommend the trainings to be performed to be programmed in such a way to cover all motoric features.

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