The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers

Efeito de exercícios plyométricos de seis semanas com protocolo tabata em algumas propriedades biomotoras em jogadores do sexo masculino U-16

Tahir Volkan Aslan¹
Muhammed Zahit Kahraman²

Abstract

In modern football, physiological assessments are becoming increasingly important for optimal performance not only in adults but also in youth. The aim of this study was to investigate the effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male football players. The athletes were randomly divided into 2 groups as experimental (n:12) and control (n:12). The plyometric exercise programme was applied to the experimental group in addition to their own football training 2 days a week for 6 weeks, while the control group only participated in football training. The normality level of the data was determined by Shapiro-Wilk test. Independent Sample T Test for independent groups and Paired Sample T Test for dependent groups were used to analyse the normally distributed data. According to the research findings, a statistically significant difference was found in the pre-test - post-test measurement values of all performance tests of the experimental group and between all performance tests (T-Agility, 20-m sprint, vertical jump, flamingo balance and long jump standing) of the experimental and control groups (p < 0.05). No significant difference was found in the control group (p>0.05). In conclusion, it can be said that six-week plyometric exercises applied with Tabata protocol

¹ PhD in Physical Education and Sport, Mersin University, Çiftlikköy, Mersin Ünv., 33110 Yenişehir/Mersin, Turkey. E-mail: tahirvolkanaslan@gmail.com Orcid: https://orcid.org/0000-0002-5839-1927
² PhD in Physical Education and Sport, Muş Alparslan University, Diyarbakır Yolu 7. km, 49250 Merkez/Muş, Turkey. E-mail: mzkahraman04@gmail.com Orcid: https://orcid.org/0000-0003-1295-7611
The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers. In this context, it can be stated that plyometric exercises added to training plans can be used as an effective method in the development of performance parameters of athletes.

**Keywords:** Plyometric Exercise. Biomotor Properties. Football. Tabata.

**Resumo**

No futebol moderno, as avaliações fisiológicas estão se tornando cada vez mais importantes para o desempenho ideal não apenas em adultos, mas também nos jovens. O objetivo deste estudo foi investigar o efeito de exercícios plyométricos de seis semanas com o protocolo tabata em algumas propriedades biomotoras em jogadores de futebol masculino Sub-16. Os atletas foram divididos aleatoriamente em 2 grupos como experimental (n:12) e controle (n:12). O programa de exercícios plyométricos foi aplicado ao grupo experimental, além de seu próprio treinamento de futebol 2 dias por semana durante 6 semanas, enquanto o grupo de controle só participou do treinamento de futebol. O nível de normalidade dos dados foi determinado pelo teste de Shapiro-Wilk. O Teste T de Amostra Independente para grupos independentes e o Teste T de Amostra Emparelhada para grupos dependentes foram usados para analisar os dados normalmente distribuídos. De acordo com os achados da pesquisa, foi encontrada diferença estatisticamente significativa nos valores de medição pré-teste - pós-teste de todos os testes de desempenho do grupo experimental e entre todos os testes de desempenho (T-agilidade, velocidade de 20 m, salto vertical, equilíbrio flamingo e salto em distância) dos grupos experimental e controle (p < 0,05). Não foi encontrada diferença significativa no grupo controle (p>0,05). Em conclusão, pode-se dizer que os exercícios de plyometric de seis semanas aplicados com o protocolo de Tabata foram eficazes no desenvolvimento de algumas propriedades biomotoras em jogadores de futebol masculino Sub-16. Neste contexto, pode-se afirmar que os exercícios poliométricos adicionados aos planos de treinamento podem ser usados como um método eficaz no desenvolvimento de parâmetros de desempenho dos atletas.


**Introduction**

The aim of child and youth training is to provide sportive performance development with training science and pedagogical tools (Muratlı, 1997). In the 12-16 age period, when...
children’s body development and growth are high, sports-based education starts to come to the agenda. As a matter of fact, anthropometric and physiological evaluations for high performance come into play in this period. In countries that develop successful athletes for the future, great importance is given to adolescents. In England, Taner, in his scientific researches, has documented that young people in this age period go through the fastest developmental periods. In this period when the characteristics of the sexes are clearly revealed, the enthusiasm and physical performance differences of boys and girls become apparent (Erkan, 2000).

Plyometric training develops jumping and speed skills which are important for volleyball athletes and provides endurance skills that enable the athlete to maintain this performance in the competition (Bayraktar, 2010). Although various methods are used in the development of endurance, it has been stated that one of the effective methods in endurance development is the Tabata Method. Tabata was developed in 1996 in Tokyo, Japan at the Japan National Institute of Fitness and Sports under the direction of Dr. Izumi Tabata. Dr Tabata reported that the oxygen consumption capacity of the subjects increased by 14% and anaerobic capacity increased by 28%. This training protocol consists of 8 sets of 20 seconds of very high intensity work at 170% of VO2 max at four minute intervals, followed by 10 seconds of rest. A well-trained athlete can increase his/her performance by 2% in 7 weeks by applying this method 3 days a week (Tabata et al., 1996).

Plyometric exercises are training techniques used by athletes to realise power and explosiveness in all sports (Chu, 1998). Plyometric exercises involve rapid stretching of the muscle (eccentric movement) followed by contraction or concentric movement of the same muscle or nearby tissue (Baechhle and Earle, 2000). The elastic energy stored in the muscle serves to produce more force than the concentric movement alone would produce (Asmuusen and Bonde-Peterson, 1974). Researchers have shown that plyometric training, when used in conjunction with periotised strength training, contributes to improved vertical jump performance, acceleration, leg strength, muscle power, joint sensitivity, and the body's ability to sense and adapt to movement (Adams et al., 1992; Bebi et al, 1987).

Based on the physiological principles mentioned above, plyometric training optimises the neuro-mechanical mechanisms involved (Markovic and Mikulic, 2010) and has the potential to improve sports performance in athletic populations. Previous studies have evidenced the effects of plyometric training on skill performance and the results are extremely positive. For example, Komal and Singh (2013) showed that 8 weeks of plyometric training had a significant effect on dribbling and quick shooting performance of
The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers.

Basketball players. Hall et al. (2016) found that the implementation of a 6-week PT programme can contribute to the improvement of jumping performance of competitive gymnasts. Rubley et al. (2011) found an improvement in the shooting performance of soccer players after a 14-week plyometric programme. At the same time, plyometric training has been shown to be effective in improving athletes' physical performance (e.g., sprinting, jumping, muscle strength, balance, endurance, agility, and flexibility) regardless of age, gender, training experience, and competition level (Bouteraa et al; Jlid et al, 2020; Tammam and Hashem, 2020; Ahmadi et al, 2021; Rojano Ortega et al, 2021; Romero et al, 2021; Sáez De Villarreal et al, 2021; Kim et al, 2022; Kosova et al, 2022, Duyan et al., 2022, Özdemir et al.,2018).

Elastic strength or quick strength is one of the determining factors of performance in sports such as football, which requires changing direction, and plyometric exercises are important in football to improve the efficiency of changing direction, maintaining and maintaining balance. Therefore, as in other team sports, the capacity to make fast and powerful movements is one of the most important skills to be acquired to improve performance in football. In the light of this information, our study aimed to contribute to the literature by investigating the biomotor effects of plyometric exercises on U 16 male football players.

Methodology

2.1 Participants

The sample of the study consisted of 24 male football players from the same football club academy playing football in the U-16 category. The athletes were randomly divided into 2 groups as Experimental (n:12) and Control (n:12). In the selection of the athletes, the criteria of not having a neurological and physiological disease, vestibular-visual disturbance in the last year and not having a serious lower extremity injury in the last 6 months were sought. This study was approved by the Muş Alparslan University Scientific Research and Publication Ethics Committee with the number 2023-99016 and was conducted in accordance with the Declaration of Helsinki.
2.2 Experimental Design of the Study

The plyometric exercise programme was applied to the experimental group in addition to their own football training 2 days a week for 6 weeks, Tuesday and Friday, while the control group only participated in their own football training. Experimental group athletes performed a 4-minute series consisting of 4 movements (Jump Burpee, Half Squat Jump, Split Lunge Jump and Tuck Jump) with a total of 8 intervals based on 20 seconds work and 10 seconds rest according to Tabata Protocol 2 days a week in addition to their weekly routine branch training. This series consisted of 4 sets in total and 2 min rest intervals were given between the sets. (Table 1). The athletes in the control group only participated in the current football training. In the study, anthropometric measurements (height and weight measurements) and motoric tests will be applied to the athletes in the experimental and control groups as pre-tests before starting the study. After the end of the six-week training programme, post-tests were applied to both groups and the data collection phase was completed (Figure 1).

<table>
<thead>
<tr>
<th>Week</th>
<th>Exercise time</th>
<th>Number of sets</th>
<th>Rest between exercises</th>
<th>Rest between sets</th>
<th>Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>20 sec</td>
<td>4</td>
<td>10 sec</td>
<td>2 min</td>
<td>Jump Burpee, Half Squat Jump, Split Lunge Jump, Tuck Jump</td>
</tr>
</tbody>
</table>

Table 1: Plyometric Exercise Programme
Source: Author

Figure 1: Experimental design.
Source: Author
2.3 Data Collection Tools

2.3.1 Body weight and height measurement

The height of the athletes was measured with a stadiometer (SECA, Germany) with a precision of 0.01 m in an upright standing position without shoes and with the big toes and heels of both feet together, in accordance with the measurement technique. Body weights were measured with Tanita BC 730 Body Analysis Scale with bare feet and wearing only shorts and t-shirt.

2.3.2 Vertical jump test

Microgate Witty (Bolzano, Italy) brand jump mat was used for the vertical jump test. The athletes were asked to squat with their hands on their waist until their knees were bent 90 degrees and jump as fast as possible. The jump heights of the athletes were measured in cm and the best degrees were recorded after two trials.

2.3.3 Standing long jump

In the standing long jump test, the athlete stands at the beginning of a steel metre with the number "0" placed on a line, with the metre tape in the middle of both feet. The athletes are asked to jump the longest distance they can jump. After the jump, the athletes were measured by determining the last points left behind. In order for the measurements to be reliable, the test was applied to the athletes twice and the good score was recorded (Hoffman, 2006).

Figure 2: Standing long jump test
Source: Author
2.3.4 20-m Sprint Test

The purpose of the test is to measure acceleration speed. The 20 m sprint measurements of the subjects were taken by warming up for 10 minutes before the test and running one by one on a flat ground on the running track at a distance determined as 20 m between the start and finish line. Athletes were warned to run the distance at maximal speed. An electronic photocell device (SE-167, Turkey) was placed at the start and end point of the 20 m running track and the athletes started the speed run 50 cm behind the start line and completed the test. The athletes were measured twice with rest intervals of 3 minutes each and the best time was recorded in seconds/rpm (Özdemir, 2013).

2.3.5 T Agility Test

The Agility T Test is widely used as a standardised test of agility performance. This test is performed by reaching cones arranged in a T-shape. After a 10-metre sprint forward, the test is completed by running laterally at a 90° angle to cones located 5 metres to the left and right, and then running backwards for 10 metres. The athlete was tested twice with a photocell (SE-167, Turkey) and the best time was recorded (Gamble, 2012).

2.3.6 Flamingo Balance Test

The balance parameter measurements of the athletes participating in the study were measured with the flamingo balance table. The athletes tried to stand on the balance table made of wood with a length of 50 cm, a height of 4 cm and a width of 3 cm for 1 minute. The time was stopped when the athlete's balance was disturbed, that is, when he/she let go of the foot he/she was holding, fell from the stand to the ground or any part of his/her body touched the ground. When the athlete got back on the balance table and regained his/her balance, the time was resumed from where it was stopped. For 1 minute, the test was continued in this way. At the end of the time, each fall of the athletes was counted and this number was counted and recorded as the balance score of the athlete at the end of the test, that is, when the time was completed (Deforche et al., 2003).
2.4 Data Analysis

SPSS 22.0 package programme was used for statistical analysis of the data. Normality levels of the data were determined by Shapiro-Wilk test. Parametric tests were preferred in the analysis of normally distributed data. Independent Sample T Test for independent groups and Paired Sample T Test for dependent groups were used and significance level was accepted as 0.05 in statistical comparisons.

**Results**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>n</th>
<th>( \bar{x} \pm Sd )</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (year)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>15.66±.49</td>
<td>.405</td>
<td>.689</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>15.58±.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>173.91±6.18</td>
<td>1.584</td>
<td>.127</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>170.33±4.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Body Weight (kg)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>61.56±7.18</td>
<td>.487</td>
<td>.631</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>60.16±6.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Results Related to General Characteristics of Groups

*cm: centimetres  kg: kilogram
Source: Author

According to Table 2, there was no statistically significant difference between the experimental and control groups in terms of general characteristics (p>0.05).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>n</th>
<th>( \bar{x} \pm Sd )</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T-Agility Test (sec)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>10.67±.71</td>
<td>-.500</td>
<td>.622</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>10.80±.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>20-m Sprint (sec)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>3.44±1.11</td>
<td>-.198</td>
<td>.845</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>3.45±1.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vertical Jump (cm)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>33.39±4.10</td>
<td>.277</td>
<td>.784</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>32.98±3.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flamingo Balance</strong></td>
<td>Experimental</td>
<td>12</td>
<td>5.33±1.92</td>
<td>-.105</td>
<td>.918</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>5.41±1.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Standing long jump (cm)</strong></td>
<td>Experimental</td>
<td>12</td>
<td>201.08±8.88</td>
<td>.611</td>
<td>.547</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>198.50±11.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Comparison of the Pre-Test Values of the Groups

*p<0.05  sec: second  cm: centimetres  kg: kilogram
Source: Author

According to Table 3, there was no significant difference between the T Agility Test, 20 m sprint, vertical jump, flamingo and standing long jump pre-test values of the athletes in the experimental and control groups (p>0.05). The fact that there was no significant difference between the initial values of both groups (p>0.05) shows that these groups have similar characteristics.
According to Table 4, a statistically significant difference was found between the experimental and control group athletes in T Agility test, 20 m sprint, vertical jump, flamingo balance and standing long jump posttest values (p<0.05).

In the T Agility test, the post-test values of the athletes in the experimental group (10.05±7.7) were lower than those in the control group (10.69±6.2). In the 20 m sprint test, the posttest values of the athletes in the experimental group (3.33±0.9) were lower than those in the control group (3.42±1.2). In the vertical jump test, the post-test values of the athletes in the experimental group (36.92±3.45) were higher than those in the control group (33.53±2.66). In the flamingo balance test, the post-test values of the athletes in the experimental group (4.1±1.02) were lower than those in the control group (5.33±1.61). In the standing long jump test, the post-test values of the athletes in the experimental group (211.16±5.23) were higher than those in the control group (200.16±5.11).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>n</th>
<th>x̄±Ss</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>T- Agility Test (sec)</td>
<td>Experimental</td>
<td>12</td>
<td>10.05±7.7</td>
<td>-2.234</td>
<td>.036*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>10.69±6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-m Sprint (sec)</td>
<td>Experimental</td>
<td>12</td>
<td>3.33±0.9</td>
<td>-2.121</td>
<td>.045*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>3.42±1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Jump (cm)</td>
<td>Experimental</td>
<td>12</td>
<td>36.92±3.45</td>
<td>2.685</td>
<td>.014*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>33.53±2.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flamingo Balance</td>
<td>Experimental</td>
<td>12</td>
<td>4.1±1.02</td>
<td>-2.111</td>
<td>.046*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>5.33±1.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing long jump (cm)</td>
<td>Experimental</td>
<td>12</td>
<td>211.16±5.23</td>
<td>5.206</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>12</td>
<td>200.16±5.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Comparison of Experimental Group Pre-Test and Post-Test Values
*p<0.05  sec: second  cm: centimetres  kg: kilogram
Source: Author

When the pre-test - post-test measurement values of the participants were analysed in Table 5, a statistically significant difference was found between the pre-test and post-test values of T Agility Test, 20-m sprint, vertical jump, flamingo balance and standing long
jump of the athletes in the experimental group (p<0.05). The T Agility test posttest values (10,05±,77) were lower than the pre-test values (10,67±,71), 20-m sprint posttest values (3,33±,09) were lower than the pre-test values (3,44±,11), flamingo balance posttest values (4,16±1,02) were lower than the pre-test values (5,33±1,92). Vertical jump posttest values (36,92±3,45) were higher than pre-test values (33,39±4,10) and standing long jump posttest values (211,16±5,23) were higher than pre-test values (201,08±8,88).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>n</th>
<th>x̄±Sd</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>T Agility Test (sec)</td>
<td>Pre-test</td>
<td>12</td>
<td>10,80±,53</td>
<td>.821</td>
<td>.429</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>10,69±,62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-m Sprint (sec)</td>
<td>Pre-test</td>
<td>12</td>
<td>3,45±11</td>
<td>.527</td>
<td>.608</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>3,42±12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Jump (cm)</td>
<td>Pre-test</td>
<td>12</td>
<td>32,98±3,13</td>
<td>-1,333</td>
<td>.209</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>33,53±2,66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flamingo Balance</td>
<td>Pre-test</td>
<td>12</td>
<td>5,41±1,97</td>
<td>.266</td>
<td>.795</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>5,33±1,61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing long jump (cm)</td>
<td>Pre-test</td>
<td>12</td>
<td>199,33±15,70</td>
<td>.303</td>
<td>.768</td>
</tr>
<tr>
<td></td>
<td>Post-test</td>
<td>12</td>
<td>198,00±7,28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Comparison of Control Group Pre-Test and Post-Test Values
*p<0.05 sec: second cm: centimetres kg: kilogram
Source: Author

According to the results in Table 6, no significant difference was found between the pre-test and post-test values of the athletes in the control group in the T Agility Test, 20-m sprint, vertical jump, flamingo and long jump values (p>0.05).

**Discussion**

Nowadays, football branch, which has an important place in international sports organisations, has become one of the most popular sports branches in the world with its large audience where physical, mental and basic motoric properties are at the forefront as well as technical-tactical capacity. In order to achieve a high level of sportive performance in football, it is necessary to improve both individual and team fitness along with increasing the technical-tactical capacity of the athletes (Bloomfield et al., 2007; Helgerud et al., 2001). Plyometric training is a type of strength training widely used in team and individual sports to improve sport-specific performance (Davies et al, 2015; Sammoud et al., 2019). Plyometric exercises have been shown to be an effective method to improve a number of physical attributes such as strength and jump height (Oxfeldt et al., 2019), running economy (Lum et al., 2019), agility (de Villarreal et al., 2008), sprint speed and endurance (Van de

Revista Gestão e Secretariado (GeSec), São Paulo, SP, v. 14, n. 10, 2023, p. 18019-18037.
Hoef, 2019). The exercises in plyometric training are characterised by explosive muscle elongation and contraction (Davies et al. 2015). With plyometric training, a significant increase in explosive strength is observed in parallel with the increase in intramuscular coordination level and the development of maximal strength. In addition, since the loading intensity can be adjusted in plyometric training, it can be applied by athletes of all ages and strength levels (Muratlı et al., 2007).

Since football is a sport in which intense struggles are experienced among players, the biomotor performance levels of players are critical for success in competitions. In this study, it was aimed to investigate the effect of six-week plyometric exercises with Tabata protocol on some biomotor properties of U-16 male football players. In this study, while there was no significant difference between the pre-test and post-test values of the athletes in the control group in the T Agility Test, 20-m sprint, vertical jump, flamingo balance and standing long jump values, a statistically significant difference was found between the pre-test and post-test values of the experimental group U-16 football players in all performance tests (T Agility Test, 20-m sprint, vertical jump, flamingo balance and standing long jump). When the post-test results of the experimental and control groups were compared, statistically significant differences were found in favour of the experimental group in all parameters (T Agility Test, 20-m sprint, vertical jump, flamingo balance and standing long jump). The literature reports positive effects on explosive power in relation to improvement in vertical jump, agility and sprint performance after plyometric training (Slimani et al., 2016; Wang and Zhang, 2016; Yanci et al., 2016).

Agility, which is based on the ability to quickly change the body's position, is the result of a combination of strength, speed, balance and coordination (Draper and Lancaster, 1985; Meylan and Malatesta, 2009). In the literature, Renfro (1999) investigated the effect of 8-week plyometric training on agility using t-test. It was determined that the average values, which were 11.85 seconds before the training, improved after the training and decreased to 11.58 seconds. In a study conducted on 15-year-old football players, it was reported that the agility test post-test averages of the athletes participating in the study were better (Hazır et al., 2010). However, many researchers (Ramirez Campillo et al, 2014; Meylan and Malatesta, 2009; Miller et al., 2006; Pienaar and Coetzee, 2013), which are in parallel with the results of our study, have reported positive improvement in agility test time after plyometric training. When we look at our results, which are in parallel with the literature, it is seen that plyometric training, one of the strength training types, improves agility.
Speed, which is defined as the level of differentiation in movement speed, means sudden positive acceleration over time, increasing sprint speed (Petrakos et al 2016). Sprint races, boxing, fencing, hockey, team sports and many similar sports, speed is a determining factor (Bompa, 1998). In order to be successful in every branch of sport, a certain level of speed is needed, albeit at different levels (Dündar, 1998). In a study examining the effects of plyometric training on speed and jump performance in elite young footballers, significant improvements were found in speed parameters (Beato et al., 2018). When the pre-test and post-test measurement values of the experimental and control groups were examined, it was determined that the measurement values differed in the comparison of 20 m sprint values within and between groups. When the mean values were compared, it was determined that the measurement values of the plyometric training group were better. Asadi et al. (2018) found that plyometric training can help improve pre-season short-distance sprint and jump performance in young footballers. There are other studies that are similar to our research findings (Sohnlein et al., 2014; Vaczi et al., 2013). Considering that speed is the least improvable feature among the improvable biomotor abilities, it can be accepted that the strength feature that develops due to the nature of plyometric training contributes positively to the existing speed potential.

Vertical jumping, which is a physical characteristic that should be taken into consideration for high-level performance, varies in importance depending on the position in football. Explosive strength, which is associated with high level performance, is important in sports such as football (Stolen et al., 2005). As a matter of fact, researchers state that these characteristics can be developed with plyometric training (Cronin et al., 2000 and Martel et al., 2005). When the pre-test and post-test measurement values of the experimental and control groups were analysed, it was determined that the measurement values differed in the intra-group and inter-group comparison of the vertical jump values. When the mean values were compared, it was determined that the measurement values of the plyometric training group were better. Carvalho et al., (2014) found that as a result of 12-week plyometric and strength training, the lower extremity strength and vertical jump height of the athletes in the Portuguese handball league increased. Similar results were found in the studies conducted by Spieszny and Zubik (2018) and Cherif et al., (2012). Previous studies (Ateş et al., 2007; Martel et al., 2005; Sağiroğlu, 2008; Polman et al., 2004; Wu et al., 2009) support our study findings. In line with the results obtained, it is seen that plyometric training methods in addition to classical football training improve jump performance more.
Balance is a continuous process that maintains vertical alignment of the centre of mass above the base of support (feet). Postural control is based on feed-forward and feedback mechanisms that produce sensory information through the visual, vestibular and proprioceptive systems that are integrated and processed within the central nervous system, resulting in effective and coordinated neuromuscular responses (Brachman et al., 2017). When the pre-test and post-test measurement values of the experimental and control groups were examined, it was determined that the measurement values differed in the comparison of vertical jump values within and between groups. When the mean values were compared, it was determined that the measurement values of the plyometric training (experimental) group were better. Balance is an important prerequisite not only for the fulfilment of daily tasks and prevention of falls, but also for the successful performance of sport-specific skills in athletic populations (Boccolini et al., 2013). Ramachandran et al., (2021) examined the effects of plyometric training on balance performance and stated that balance performance improved. In the study examining the effect of plyometric training on the performance levels of shot put technique and related motor skills, it was observed that the mean values of the flamingo balance test (p<0.05) pre and post test (tests within subjects) were statistically different from the measurements over time (Thaqi et al., 2021). In line with the results obtained, it is seen that plyometric training methods in addition to classical football training improve the jumping performance more.

It has been emphasised that regular and programmed plyometric exercises positively affect performance in branches such as football, volleyball, basketball and handball where jumping is prominent (Reyment et al., 2006). When the pre-test and post-test measurement values of the experimental and control groups were examined, it was determined that the measurement values differed in the intra-group and inter-group comparison of the vertical jump values. When the mean values were compared, it was determined that the measurement values of the plyometric training group were better. In the study of Pancar et al. (2018) on handball training programme combined with plyometric exercises, it was found that there was a significant difference in the values of standing long jump and vertical jump of the exercise group compared to the control group. In a different study (Çakmak, 2001), horizontal jump and vertical jump values in 13-15 age group male football players who applied plyometric training 3 days a week were significantly higher than the control group. In the study of Aykora and Dönmez (2017), it was reported that at the end of the plyometric training programme applied with tabata programme for 8 weeks to 64 female volleyball athletes aged 16-17 years, a significant difference was found between the pre-test
and post-tests of the group to which plyometric programme was applied, and a significant improvement was reported in vertical jump, long jump and dunk jump performances. Although plyometric exercises are one of the recommended training methods to increase strength in stretching and running speed, they lead to improvements in performance especially in activities requiring explosive muscle contractions (Malisoux et al., 2006). The results of the present study and the literature findings support each other. In a study conducted in the literature, there was no statistically significant difference between the control group and the experimental group in the long jump test as a result of plyometric training applied 3 days a week (Taşkan, 2020). It is thought that this difference in the studies may be due to reasons such as the variety of subject groups included in the studies, differences in the application time and intensity of the preferred methods.

With the data obtained, it was determined that plyometric training applied for 6 weeks had a statistically significant effect on jump and balance performance, improved the time to finish the running distance in T agility and 20-m sprint measurement, and supported the increase in jump distance in the standing long jump test. In this direction, it is thought that plyometric training positively affects the performance parameters of the athletes.

**Conclusion**

In conclusion, it can be said that six-week plyometric exercises applied with Tabata protocol were effective in the development of some biomotor properties in U-16 male football players. In this context, it can be stated that plyometric exercises added to training plans can be used as an effective method in the development of performance parameters of athletes. In future researches, researches to be planned in various age groups, in different sports branches, using different techniques or grounds may allow a wider perspective evaluation of the studies.

**References**


The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers


The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers


The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers


The effect of six-week plyometric exercises with tabata protocol on some biomotor properties in U-16 male footballers


Taşkan, B. (2020). Determination of the Effects of 8-Week Plyometric Training on Some Selected Parameters Applied to Volleyball Players. Kirikkale: Kirikkale University Institute of Health Sciences Department of Movement and Training.


Submetido em: 15.09.2023
Aceito em: 18.10.2023