THE IMPACT OF PLYOMETRIC TRAINING PROGRAM ON SPRINTING SPEED AND JUMPING ABILITY IN AMERICAN FOOTBALL PLAYERS OF A GERMAN AMATEUR CLUB

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Keywords: plyometric training, speed, jumping ability, American football

Abstract:

Background: The profile of requirements for an American Football game is characterized by good sprinting and jumping performance. The literature highlights the benefits of plyometric training on sprinting speed and jumping ability. Due to an increasing professionalization of American football in Germany, a transfer to the training practice is obsolete.

Aim: The aim of the study was to determine the impact of additional participation in a plyometric training program on sprinting speed and jumping ability of players of the American Football Team in Germany.

Material and Methods: The study was conducted in May 2014, with 20 players of an amateur American Football Club in Germany including the treatment group of 10 participants (age: 22.44 ± 3.4 years) and the control group of 10 participants (age: 17.10 ± 1.20 years). The treatment group followed a plyometric training routine once per week for 2 months while the control group was attending only the team training. The variables assessed at baseline and after 2 months included the speed measurements of a 30 m sprint and acceleration in the first 5 m, and the results of CMJ, SJ, and DJ performed from the heights of 16cm, 24cm, and 32cm.

Results: Analysis of variance did not confirm statistically significant improvements in sprint time in the 30m sprint and jumping performance in SJ and DJ in the treatment group. The sprint time in the first five meters of the 30-meter sprint showed a highly significant increase of 1.66%. In the CMJ, a marginally significant increase in jump height of 6.37% was found.

Conclusions: significant improvements as a result of the plyometric strength training can be only found in the jump height in the CMJ. In order to reach more comprehensive conclusions, physical fitness of the subjects, a longer intervention duration, and a higher training volume should be taken into account in future studies.

Introduction

American football was introduced in Germany after World War II by US occupation soldiers. The sport had not attracted much interest until the late 1970s, when the first clubs were founded [1].

In 1982, all clubs joined together to form today’s American Football Association in Germany. With the establishment of the national competitions, more and more locals found their way into the sport as active players. Since then, there has been a continuous increase in the number of clubs and members [2].

In 2017, the American Football Association in Germany had 450 clubs and 60,361 members. That year saw a 9.14% increase in membership, which translates into an increase of 5,056 [3].
The German Football League (GFL) is a Germany’s top division of American football and the figurehead of the American Football Association in Germany. The renaming of the First Bundesliga to GFL took place in 1999 as part of the popularization of the sport [4].

Recently, American football has been an integral part of amateur sports in Germany, and, with the introduction of the German Football League, there have been tendencies towards professionalization of the sport in Germany [5].

Despite this development, the focus of the American Football Association in Germany is on amateur sport and the mediation of values that put the fun of the game and the desire to exercise in the foreground. Most GFL clubs are designed for the concept of mass and leisure sports and very few clubs have a professional framework [6].

Consequently, there are numerous differences in the training practice in the USA, especially in the training of the players. In the USA, American football is already being played in equipment and taught in schools’ sports classes at the age of five. In Germany, contact sport is only allowed from the age of 15. In the United States, strength training with free weights is already practiced before the age of 14. The main training goals are agility, quick changes of direction, and high running speed. From high school (at the age of 15), with increasing intensity of the game, body size and explosiveness come more into focus as training goals. From the age of 17, emphasis is primarily placed on strength and size. For this purpose, high school athletes already have access to huge training and fitness facilities with close supervision in order to guarantee the optimal, age-related, and sport-specific training. In Germany, attempts to introduce American football as a new sport in schools have so far failed. It is mostly young people at the age of 16 or 17 who find their way into American football and therefore the basics of the sport have to be taught in Germany for the first time at this age. Introduction to regular strength and athletic training starts only in adult teams and is performed, for the most part, only in the preparation season [5].

American football is a game characterized by alternating phases of short actions at maximum intensity. An average of 14.4 attacks are played in the NFL games. The average duration of an attack is about 5.0 seconds and the average pause length between the exercise is between 29.6 and 36.4 seconds [7].

From this it follows that American football is mostly characterized by high-speed loads with anaerobic alactic energy supply. Due to the time structure of the game, there are breaks that allow for complete recovery [7].

Given the course of the game, the tasks of the individual players, and the temporal structure of the game, it becomes clear that explosive power plays a decisive role in American football [7, 8, 10]. Short sprints and jumps are required in almost all situations [7, 8]. A maximum jump is required to catch the ball in the air after the kickoff or punt, to block a PAT or field goal [8]. When intercepting the ball by the defense or getting the ball out of the air in the end zone, an optimal jumping height is important. Short sprints come into play in all attempts to gain space. Crucial here is the start on the first three to five yards. A 40-yard sprint occurs during a touchdown [8]. The importance of maximum acceleration is also illustrated by the numerous changes of direction that are required to assert yourself between defenders [7, 8].

Optimal explosive strength is essential to meet the requirements of the game.

A study by Grützer & Weineck (2003) clearly showed the importance of maximum strength for football players. These take first place in the ranking list with other sports, some at top-level sports [9].

Smith & Kramer (1979) emphasized the importance of maximum power when blocking, tackling, and pushing opposing defenders [8].

The different position-related specific requirements show the essential importance of a pronounced sprint speed on the first yards, a good final speed for distances is between 40 yards, and maximum jumping power [10-13].

Line players should be particularly tall, broad, and muscular and have a high level of strength [11]. They are rarely required to sprint more than 10 m [12]. While line players are expected to be tall and heavy, they must be able to move their body mass quickly. For a quick start, in order to get to the opponent who is to be blocked or tackled as quickly as possible, a pronounced sprint speed of over 3 yards is required [14].

Wide receivers and defensive backs are mostly required to run distances of 30 or 40 m [12]. They should be characterized by high sprinting and jumping abilities since they have to cover longer sprint distances as quickly as possible and jump high to catch a ball in the air [13].

Running backs should be quick and agile to carry the ball as far forward as possible before being tackled, but they must also have sufficient strength and mass to withstand tackles [5].

The linebackers are between the line players and backs and wide receivers in terms of strength and speed values. They should have both a pronounced speed and jumping power to intercept the ball and prevent short passes as well as a high level of maximum strength to help the ball carrier to tackle running plays [13].

As far as the stature of the center is concerned, there are different opinions. Christensen and Peterson (1998) believe that a smaller and not too heavy center is better compared to other line players because he or she can move
faster between players and has better coordination [11]. Kraft (1992), on the other hand, claims that the size and mass of a center is an advantage because the quarterback can hide behind them [14]. There are both large and smaller centers in the NFL [13].

In conclusion, it should be noted that the high-speed performance in American football is the basis for any game action and is therefore decisive for success [7-14]. Consequently, the focus in training practice should be on the evaluation and subsequent optimization of the above-mentioned explosive strength performance.

Plyometric training includes different variations of sprints and jumps. The countermovement jump (CMJ) and drop jump (DJ) are performed as training exercises for the effective development of explosive strength for high-speed performance. The activation of the CNS learnt during the jumps is transferred to other sport-specific movements. Maximum intensity with each jump is decisive in explosive strength training, which means that the maximum height of CMJ and the highest possible reactive strength index (RSI = jump height/ground contact time) of DJ are to be aimed for [15,16].

Research shows that strength training can lead to improved power, strength, and speed [17]. Hoffman and Kang (2003) reported improvements in lower-body strength of American football players from the National Collegiate Association Division III during their in-season resistance training program [18]. Stodden and Galitski (2010) examined the longitudinal effects of a strength and conditioning program on, among other things, the 40-yard sprint and vertical jump of collegiate American football players. This study showed the greatest rate of improvement in the selected performance parameters was observed in the first year of the training intervention [17].

A review of the current literature review shows no studies on the trainability of high-speed performance in amateur American football players in Germany. Based on the above observations, the aim of this study was to examine the effects of sport-specific training on the sprint speed and jumping ability of an amateur American football team.

Material and Methods

Study group

Twenty players of an amateur American Football Club in Germany were examined (Tab. 1).

The treatment group consisted of 10 players from a male team playing in the 5th league. At the time of the study, the team trained three times a week for 90 minutes and played championship games at weekends.

Ten players from the male youth team playing in the second-highest youth division of American football in Germany were recruited as a control group. At the time of the study, the team completed two 90-minute training sessions a week and played one championship game a week.

All athletes participated in the study voluntarily. The requirements to participate were a condition free from injury and acute or chronic diseases that participants previously declared and attendance at the training sessions, and pre- and post-tests. The treatment group included only players who were eligible to play in the male team and were therefore over the age of 19. The intervention group included only players who were eligible to play at the youth level and in this case were between 15 and 19 years old.

Table 1. Basic somatic characteristics of the participants (x; s)

<table>
<thead>
<tr>
<th>group</th>
<th>N</th>
<th>age [years]</th>
<th>body height [cm]</th>
<th>body mass [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>treatment group</td>
<td>10</td>
<td>22.44 ± 3.4</td>
<td>178.00 ± 12.60</td>
<td>78.44 ± 10.68</td>
</tr>
<tr>
<td>control group</td>
<td>10</td>
<td>17.10 ± 1.20</td>
<td>180.00 ± 7.56</td>
<td>80.10 ± 8.76</td>
</tr>
</tbody>
</table>

Research procedure

The study started with the evaluation of the age and height of the participants based on interviews. Body weight was measured on personal scales (Silvercrest Personal Care). The pretest was carried out at 6 p.m. at the team’s usual training location, i.e. a stadium. After a short general warm-up, the sprinting speed and jumping ability were measured.

A distance of 30 meters was chosen for the sprint measurement. To ensure high reliability, the pre- and post-tests took place on the same section of the football stadium’s tartan track. A double light barrier system was used for the measurement. The light barriers were set up at the start, after 5 meters, and after 30 meters. The recorded speeds
were transferred to a computer connected to the light barrier system. The subjects wore sportswear and running shoes. The start took place approx. 80 cm before the first light barrier from a standing position (slight step position). The subjects were instructed to start independently without a signal. Each player ran only once. The order of measurement was identical in both the pre- and post-tests. The weather conditions in the pre- and post-training testing differed only slightly.

Jumping ability was evaluated based on measurements of the height of the countermovement jump, squat jump, and drop jump, ground contact time, and reactive strength index of the drop jump. First, the subjects performed three tests of the countermovement jump, then of the squat jump, and finally of the drop jump. Three different drop heights were used in the drop jump: 16 cm, 24 cm, and 32 cm. Similarly, the subjects had three attempts per drop height. In the case of a significant failure to perform in accordance with the technique, the trial was not counted. The trial with the highest jump height was used as a final score. The jumps were performed on a vertical jump measurement mat.

The training program started one week after the pre-test and lasted eight weeks. During this period, the treatment group completed eight athletic training sessions using plyometric methods. The training took place at the usual training location. The subjects continued to take part in regular training and games. The training sessions lasted 60 minutes and were scheduled before normal club training. Drop jumps were included in each training session. Three sets of eight repetitions with a rest period of 5 minutes were performed. The drop height was chosen individually for the participants (16 cm, 24 cm, 32 cm, and 40 cm). Another part of the jump training was the CMJ. Individually selected additional loads were used or a distance of 15 meters should be covered with as few jumps as possible. Three sets of eight repetitions with a three-minute rest between each set were performed. Each training session included sprint training. Five sprints of 30 meters each were performed, with a rest of two to three minutes between individual repetitions. The complex method and the competition method were used. In the complex method, the jump forms described above were combined with short sprints. In the competition method, additional load (resistance bands, tires) over five meters was used for the short runs.

Statistical analysis

The statistical values were calculated using the statistical program Statistical Package for the Social Sciences (SPSS). First, the Kolmogorov–Smirnov test was used to check for normal distribution. As part of the descriptive statistics, the means, standard deviations, and percentage changes were calculated. Mean differences between the two measurements were checked for significance using the t-test. ANOVA was used to assess interactions between measurement time points and groups for pre-test compared to post-test.

Results

Normal distribution was checked using the Kolmogorov–Smirnov test. Four values did not conform to the normal distribution. Jump height (p = .03) and contact time (p = .04) and DJ from a 32 cm fall height the contact time (p = .02) and the performance index (p = .01) proved to be significant for the DJ from a fall height of 24 cm and are therefore not normally distributed according to Kolmogorov–Smirnov. However, analysis of skewness, kurtosis, and histograms showed the only deviation from the normal distribution for a contact time of DJ for the drop height of 32 cm.

In the treatment group, the differences between measurement times were only significant for time of the 30 m sprint (p < .01) (Tab. 2). On the other hand, there were no significant differences between the measurement dates for time of the 5 m sprint (p = .13), jump height in CMJ (p = .07) and SJ (p = .16), and RSI for drop jumps from 16 cm (p = .1), 24 cm (p = .69), and 32 cm (p = .89).

The two-factor analysis of variance revealed a highly significant increase in the sprint time of the 5 m sprint between pre- and post-test (p < .001). No significant difference was found between the groups (p = .06). The interaction group x time (p < .05) showed a significantly higher increase in the 5 m time for the CG compared to TG between the measurement times.

In the 30 m sprint, TG recorded no significant decrease and the CG no significant increase in sprint time between measurement time points (p = .48). No significant group difference (p = 0.96) was found. The interaction group x time (p < .05) shows a significant increase in the 30 m time for the CG and a significant decrease in TG between measurement time points.

In the CMJ, TG and CG showed marginally significant increases in jump height between pre- and post-test (p = 0.051). In group comparisons (p < 0.05), TG achieved significantly higher increases in jumping performance compared to the CG. The interaction group x time (p = .17) turned out to be insignificant.
For SJ, the TG and CG groups showed no significant increase in jump height between measurement times (p = .37). In group comparisons (p < .05), there was a significantly higher increase in jumping performance in CG compared to TG. The interaction group x time (p = .66) proved to be non-significant.

No significant differences were found between the measurements taken before and after (p = .17) and the groups (p = .83) in RSI in DJ from 16 cm. The interaction group x time (p < .05) showed a significant decrease in RSI for DJ from 16 cm in CG and a significant increase in TG between the measurement time points.

RSI for DJ from 24 cm also showed no significant differences between measurement times (p = .90) and between the groups (p = .36). The interaction group x time (p = .50) proved to be non-significant.

The RSI of the DJ from 32 cm showed no significant differences between pre- and post-test (p = .839) and between the groups (p = .08). The interaction group x time (p = .64) proved to be non-significant.

### Table 2. Means (x), standard deviations (s) changes in the times in the 5-meter sprint and 30-meter sprint, jump height (JH) in all vertical jumps, ground contact time (GCT) and RSI for DJ from all drop heights for the treatment group (TG) and control group (CG) in the pre- and post-tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5m sprint (sec)</td>
<td>TG</td>
<td>10</td>
<td>1.05 ± 0.04</td>
<td>1.06 ± 0.04</td>
<td>1.66 ± 2.96**</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>10</td>
<td>0.95 ± 0.06</td>
<td>1.07 ± 0.07</td>
<td>12.61 ± 9.58**</td>
</tr>
<tr>
<td>30 m sprint (sec)</td>
<td>IG</td>
<td>10</td>
<td>4.42 ± 0.24</td>
<td>4.34 ± 0.25</td>
<td>-1.74 ± 1.12</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>4.32 ± 0.22</td>
<td>4.44 ± 0.22</td>
<td>2.69 ± 3.40</td>
</tr>
<tr>
<td>CMJ JH (cm)</td>
<td>IG</td>
<td>10</td>
<td>37.98 ± 5.26</td>
<td>40.37 ± 6.34</td>
<td>6.37 ± 9.03†</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>34.07 ± 3.66</td>
<td>34.52 ± 3.86</td>
<td>1.54 ± 7.74†</td>
</tr>
<tr>
<td>SJ JH (cm)</td>
<td>IG</td>
<td>10</td>
<td>37.04 ± 5.24</td>
<td>38.09 ± 6.05</td>
<td>2.73 ± 5.71†</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>32.16 ± 5.41</td>
<td>32.52 ± 4.13</td>
<td>2.98 ± 18.13†</td>
</tr>
<tr>
<td>DJ 16 JH (cm)</td>
<td>IG</td>
<td>10</td>
<td>30.08 ± 5.05</td>
<td>30.44 ± 4.66</td>
<td>2.76 ± 18.10</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>32.09 ± 4.70</td>
<td>31.12 ± 4.42</td>
<td>-2.83 ± 4.65</td>
</tr>
<tr>
<td>DJ 16 GCT (ms)</td>
<td>IG</td>
<td>10</td>
<td>246.33 ± 62.48</td>
<td>207.56 ± 49.51</td>
<td>-13.59 ± 18.04</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>240.20 ± 54.54</td>
<td>244.80 ± 65.37</td>
<td>1.63 ± 6.52</td>
</tr>
<tr>
<td>DJ 16 RSI (cm/ms)</td>
<td>IG</td>
<td>10</td>
<td>129.12 ± 37.82</td>
<td>153.63 ± 43.45</td>
<td>23.47 ± 30.84</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>140.59 ± 42.58</td>
<td>134.31 ± 39.85</td>
<td>-4.06 ± 7.31</td>
</tr>
<tr>
<td>DJ 24 JH (cm)</td>
<td>IG</td>
<td>10</td>
<td>32.54 ± 4.07</td>
<td>33.14 ± 4.73</td>
<td>2.37 ± 12.63</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>30.78 ± 4.76</td>
<td>30.01 ± 5.05</td>
<td>57.32 ± 182.93</td>
</tr>
<tr>
<td>DJ 24 GCT (ms)</td>
<td>IG</td>
<td>10</td>
<td>234.89 ± 70.64</td>
<td>218.44 ± 45.11</td>
<td>-2.92 ± 21.36</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>237.40 ± 73.17</td>
<td>231.90 ± 57.66</td>
<td>67.64 ± 213.03</td>
</tr>
<tr>
<td>DJ 24 RSI (cm/ms)</td>
<td>IG</td>
<td>10</td>
<td>153.18 ± 57.48</td>
<td>158.01 ± 42.39</td>
<td>9.01 ± 25.59</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>138.60 ± 40.50</td>
<td>135.27 ± 37.22</td>
<td>-1.44 ± 9.17</td>
</tr>
<tr>
<td>DJ 32 JH (cm)</td>
<td>IG</td>
<td>10</td>
<td>34.73 ± 3.53</td>
<td>33.54 ± 4.61</td>
<td>-3.35 ± 9.69</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>31.68 ± 5.00</td>
<td>31.62 ± 4.64</td>
<td>62.01 ± 197.33</td>
</tr>
<tr>
<td>DJ 32 GCT (ms)</td>
<td>IG</td>
<td>10</td>
<td>223.67 ± 49.36</td>
<td>215.78 ± 53.36</td>
<td>-2.53 ± 16.06</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>254.60 ± 64.22</td>
<td>247.60 ± 60.39</td>
<td>55.42 ± 183.13</td>
</tr>
<tr>
<td>DJ 32 RSI (cm/ms)</td>
<td>IG</td>
<td>10</td>
<td>164.40 ± 49.43</td>
<td>163.24 ± 43.45</td>
<td>0.91 ± 15.52</td>
</tr>
<tr>
<td></td>
<td>KG</td>
<td>10</td>
<td>129.94 ± 33.94</td>
<td>132.88 ± 30.50</td>
<td>3.00 ± 8.70</td>
</tr>
</tbody>
</table>

* significant difference between measurement times (p < .05)
** highly significant difference between measurement times (p < .05)
† significant group difference
Discussion

There was no significant improvement in sprint performance as a result of reactive strength training. The sprint time in the first five meters of the 30 m sprint showed a highly significant increase of 1.66%. DJ and CMJ were an integral part of all eight training sessions. In addition, the initial speed was trained on the first 5 and 10 meters using different methods. The generated training stimuli should lead to a decrease in sprint time and an improvement in RSI in drop jumps. After the eight-week training program, no significant increase in RSI for DJ was recorded. It should be noted that the intervention group was highly untrained and had no experience in drop jumps. This becomes clear from the long ground contact time while performing the drop jumps. The mean values of the ground contact time were over 200 ms, which, according to the definition of Schmidtbileicher & Haas, no longer corresponds to a short stretch-shortening cycle. There was a decreasing trend in the ground contact times in the post-test. This speaks to the effectiveness of the short stretch-shortening cycles performed in the training sessions. Despite the feedback and correction, execution of the training exercises at maximum intensity and concentration is not guaranteed while maximum intensity is decisive for reactive strength training [16].

Moore and Fry arrived at similar results regarding the lack of adaptations in speed performance through targeted athletic training. After a 15-week off-season training program, the sprint speed of division I American Football players did not increase in contrast to performance measures like vertical jump [19].

Due to the amateur character and the position-specific specialization, the starting level in relation to conditional ability was very different, so that the applied training stimuli could be too high or too low for the subjects of the test. There is a possibility that the stimulus intensity in CMJ with additional weight or sprints with resistance bands carried out during training was so high that it primarily resulted in such high levels of fatigue that the acceleration times decreased.

A fatigue-free state is an important prerequisite for the effectiveness of plyometric training [16]. This was not guaranteed in this study, as the test subjects were exposed to different stress stimuli in everyday work, school, and individual training sessions in addition to club training.

The 6.37% increase in CMJ jump height can be explained by improved activation of the central nervous system. This effect was particularly evident in the untrained subjects, since the athletes learn to better control the muscles for the target movement [15].

No significant change in jumping performance was found for SJ, although the plyometric exercises used in the training program should also lead to an increase in explosive power in concentric explosive power movements [16].

As with the lack of adjustments in the drop jumps and sprint performance, the cause for this could be the low baseline levels and the lack of motivation during training.

A comparison of the average jump height of SJ with the jump heights of top athletes in various sports showed a low baseline level in the IG group. With an average of 37.98 cm, the participants in the study are among sports students [15].

Another indication of the insufficient training status of the treatment groups is the fact that the players achieved lower values in DJ than in SJ and CMJ.

A comparison to NFL football players in terms of sprint speed is hardly feasible. The NFL players at the NFL Scouting Combine from February 20th to 26th, 2013, achieved lower sprint times for 40 yards, which corresponds to 36.67 meters, than the subjects in a 30-meter sprint [20].

According to Hunter et al., athletes may have a „greater adaptational window for physical improvements in the early stages of training“ [19]. The training experience of the test subjects was differentiated in this study, but many had taken part in club training for several years.

A study of male basketball players by Groves and Gayle (1993) showed that the time of training intervention in the year plays an important role. They reported fewer improvements in lower-body power and upper-body strength during the in-season compared with other times of the year [21]. This study was conducted during the season.

Furthermore, too low training frequency can be responsible for the lack of adjustments. Better effects might have been achieved and recorded with two athletic units within a period of eight weeks. A study by Hoffman and Kang showed that athletes attending a resistance training program two times a week had significant strength improvements [18]. One of the limitations of this study was that more training sessions were not possible for organizational reasons.

Studies examining adaptations to resistance training in athletes have mostly lasted one year [17]. In these cases, resistance training resulted in improvements in performance measurements. Therefore, the duration of this study could be a limiting factor.
Another limitation is that despite belonging to the same club and having the same head coach, there were numerous differences between the treatment and control groups. The training frequency and intensity were different. The training content varied due to different coaching teams. The average age of the youth team was lower. The level of performance and the game and training practice also varied greatly. Since these were amateur teams, the subjects, in addition to the club training, were exposed to different stresses in everyday work and individual training sessions. Other performance-determining factors that could not be controlled and that may have influenced the daily form on the test days are adequate sleep, adequate nutrition, and motivation.

Conclusions

1. A slight positive effect of the plyometric training intervention could only be determined for the jump height of CMJ.
2. Further in-depth research into high-speed performance in American football in Germany is required, with the amateur character of the German American Football teams posing a particular challenge to research.
3. In order to draw more comprehensive conclusions, a longer intervention duration and higher training volume should be taken into account.
4. The training status of amateur American Football players in Germany is insufficient.

Practical Implications

In amateur sports, it is important to combine all relevant physical fitness, technical, and tactical skills in the limited training time that is available. First of all, at the beginning of the preparation season, the basic requirements such as well-developed core muscles should be met through hypertrophy training, and then plyometric training should be introduced. One approach could be that reactive training takes place before normal training sessions. For hypertrophy training or power training, the players should receive individual plans and instructions to follow in addition to club training. It would also be helpful if all coaches were offered regular further training courses in strength training.

Institutional Review Board Statement

The research was approved by the Bioethics Committee at the University of Rzeszow (No 3/11/2017).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Conflict of Interest

The authors declare no conflict of interest.

The study was conducted in accordance with the Declaration of Helsinki.

References:

The Impact of Plyometric Training Program...


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