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**ORIGINAL ARTICLE**

# The Effects of Additional Plyometric Training on Indicators of Subjective Training Load in Football

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## ABSTRACT

**Background.** One of the most effective methods for progression in fast and explosive movements which are important in football player's performance is plyometric training which includes activities and movements whose performance depends on the stretch and shortening cycle. **Objectives.** The problem of this research is related to the monitoring of the subjective feeling of load and the feeling of physiological and psychological stress under the influence of plyometric training, and whether the said low-volume training has an impact on the internal experiences of the load of young football players. **Methods.** The sample of respondents consisted of 33 junior football players who played club football at the age of 17.3±0.9. The experimental training program lasted six weeks and subjective parameters for training load were monitored daily through RPE and wellness questionnaires. **Results.** The results of this study showed that additional plyometric training does not significantly affect the subjective feeling of load during six weeks in the participants. Significant differences between the experimental and control groups of participants were found in wellness in the first and second weeks of the experimental procedure (<0.005 and 0.017), while no significant differences were found in wellness from the third to the sixth week of the experimental procedure. **Conclusion.** Daily monitoring of the subjective feeling of load is a good tool for controlling athletes. This especially applies to younger athletes because it is an extremely effective tool that is available to everyone and does not require financial expenses.

**KEYWORDS:** ***Wellness Questionnaire, RPE, Football Training, Youth Players.***

## INTRODUCTION

The dynamics of the football game, both through training and through competition, are characterized by the alternation of high-intensity and low-intensity activities that are constantly alternating (1). Football players cover 10-13 km during a match and perform approximately 1350 activities (every 4-6 seconds), such as accelerations and stops, changes in direction of movement, and jumps (2). Given the above, the football player's capacity for performing fast and explosive movements has a high impact on the quality of the football player's performance during training and matches (3–5).

A popular and effective method for improving the mentioned activities is plyometric training (6, 7). Plyometric training is characterized by training content based on the muscle stretch and shortening cycle. The goal of plyometric exercises is to adapt the nervous and muscle-tendon systems in order to produce the greatest possible mechanical force for the shortest possible period of time (8). Given that it has already been said that the football game contains a large number of short, high-intensity activities, it can be concluded that plyometric

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training is an excellent training method for improving these important motor skills in football players (9).

Likewise, for reasons of increasing the performance level of football players and reducing the occurrence and risk of injuries, many football clubs have sports scientists in their professional staff who monitor the total training load on a daily basis (10). The total training load is most often considered through the prism of external and internal load parameters. External load parameters are most often characterized by the total distance run, the number of sprints during training or a match, the total number of stops, and other factors of external load parameters. On the other hand, internal parameters are related to the athlete's physiological response to activity, such as heart rate, blood lactate level, or the more frequently used method in football, the subjective experience of the total load during training or a match (11). In the following text, due to the goal and problems of this research, the parameters of the internal load and the influence of plyometric training on them will be explained.

Plyometric training includes activities and movements whose performance depends on the stretch and shortening cycle. The content of plyometric training is most often characterized by hops, jumps, lunges, and leaps, which can be of unilateral or bilateral character with different directions, so it is easy to conclude that plyometric training describes the speed of movement during the performance of a particular exercise. The cycle of muscle stretching and shortening is the link between strength, power, and speed. If we consider the above, this type of training increases force production and improves sports performance during training or competition. Dynamic muscle work in which the athlete overcomes a certain force at a certain movement speed is the basis of energy production, therefore muscle power is defined as the speed at which the muscles perform some work (12). Plyometric training and the contents of this type of training can be defined most simply through the type of exercise that connects muscle strength with the speed of movement (13), and depending on the time of contact with the surface, it is defined by slow (>250) and fast (<250) cycles stretching and shortening of muscles. Including plyometric training in the programs of young football players opens the possibility of improving a large number of motor skills (14) but also reducing the risk of injury (15).

The problem of this research is related to the monitoring of the subjective feeling of load and the feeling of physiological and psychological stress under the influence of plyometric training, and whether the said low-volume training has an impact on the internal experiences of the load of young football players. In this research it is also tried to determine whether additional plyometric training has significant changes in the parameters of the internal subjective training load (sRPE), and the subjective feeling of psychological and physiological stress in football players (Wellness questionnaire). Monitoring training load can be viewed in the context of maximizing training effects, reducing the incidence of injuries (16), and reducing the risk of overtraining (17). Also, due to the connection between the volume of training and the occurrence of injuries, monitoring the load in players of younger age categories is a very important factor in training (18). Research results on young athletes show that due to growth and maturation stages, a good choice of training technologies (19) but also a good distribution of training load and volume make a sports career longer (20). However, monitoring the load components can often be a problem for coaches and sports club employees, given that certain methods require a high level of professional knowledge as well as financial expenses of the club. Therefore, in this research, load monitoring variables were applied through the method of subjective load monitoring, which represents a simple, free, and effective method of load monitoring. The previous sentence can be confirmed by its high correlation with heart rate, blood parameters, and the level of lactate concentration in the blood (21). In addition, the correlation and connection with external load parameters show that subjective load assessment can be a very good tool for assessing the total training load in football players of younger age categories (22). The use of good and valid tools during each training session for the purpose of monitoring the total training load (TL - training load) is important for optimal adaptation of athletes to training and competition and for avoiding overtraining (23). According to Foster et al. (24), the method of monitoring training load based on the athlete's subjective experience

of training load (sRPE - session rate of perceived exertion) can be a good indicator of both intensity and volume of training.

The paper will analyze whether the subjective experience of training with additional plyometric training significantly differs in the parameters of subjective internal training load (sRPE), and the subjective feeling of psychological stress in football players (Wellness questionnaire). In accordance with the objectives, the following hypotheses are set:

• Additional plyometric training during the competitive season will result in significant changes in the parameters of subjective internal training load and the subjective feeling of psychological stress of football players.

• Additional plyometric training will not cause statistically significant differences between the experimental and control groups in the subjective evaluation of the load.

• Additional plyometric training will not cause statistically significant differences between the experimental and control groups in the subjective assessment of psychological stress.

## MATERIALS AND METHODS

**Ethics Committee approval.** This study was approved by the Ethics Committee of the Faculty of Kinesiology (Protocol 09/2021 on 20th September 2021), University of Zagreb, and was carried out in accordance with the Helsinki Declaration. Examinees have signed statements expressing their willingness to proceed with the research.

**Participants.** The sample of participants consisted of 33 junior football players who play club football at the age of 17.3±0.9. The respondents of this club during the experimental procedure were participants of the 2nd Croatian Football League Center in the 2020/2021 season. The research participants were randomly divided into two groups: the experimental group, which performed additional plyometric training in addition to standard football training (body height: 180.52±6.86, body weight: 69.8.0±7.2, and percentage of subcutaneous adipose tissue: 10.5±0.9) and a control group that during the experimental procedure performed standard football training, without additional plyometric training (body height: 180.40±4.88, body weight: 71.0±7.9 and percentage of subcutaneous fat tissue: 10.6±1.0). Before the experimental procedure, during the interview, the respondents received clear information that during the experimental procedure, they did not conduct additional football or fitness training.

**Procedure.** After the initial testing, the participants were randomly assigned to two groups: control and experimental. Both groups were formed by drawing pieces of paper with the names and surnames of the respondents. The total number of participants at the beginning of the measurement was 34. One subject from the control group did not complete the experimental procedure because he left the club, so the research was completed with 33 participants. The experimental group consisted of 17 participants, while the control group consisted of 16 participants. During the experimental procedure, the participants from both groups did not attend any form of additional work directed towards technical-tactical preparation or fitness preparation. The interviews with the players before the initial testing included questions about the training history in relation to plyometric training, during the conversation, it was noticed that the test participants of the experimental and control groups were familiar with the mentioned training technology, and throughout the season they practiced jumping exercises in relation to the plan and program.

During the experimental procedure lasting six weeks, 30 technical and tactical sessions, 7 matches, and five days off were realized. The experimental training program included with the experimental group four additional plyometric trainings per week before football training for 15 minutes for six weeks. Participants of the experimental group came to the football field 20 minutes before the start of training and spent extra 5 minutes of warm-up for plyometric training (front leg from skip in movement 1x6+6 repetitions each leg, legs from the skip in the movement 1x6+6 repetitions each leg, alternately shifting the weight from one leg to the other in a wide stance 1x6+6 repetitions, alternating flexion in the knee joint with pulling the leg 1x4+4 repetitions each leg, alternating heel to the floor in support of the outstretched arms 1x5+5 repetitions each leg), along with normal warm-up protocol and 15 minutes of additional plyometric training. Plyometric training included jumps of a bilateral and unilateral nature with vertical, horizontal, and lateral direction. It is important to note that the progressiveness in the intensity of

the experimental program was designed in such a way that the complexity of the content, the height of the jumps, and the number of repetitions and series increased from week to week, respecting the methodical principles of training and progressiveness (Table 1). For six weeks, the control group performed only standard football training without additional plyometric training, which was aimed at developing specific fitness preparation and perfecting the technical and tactical skills of football players.

Likewise, the experimental procedure included the monitoring of the subjective feeling of exertion (sRPE) at the end of the training. Participants of the experimental and control groups evaluated the subjective feeling of training load on a scale of 1-10, exactly 30 minutes after the training (24). The respondents were familiar with the evaluation of the feeling of the training load since throughout the entire season they evaluated their subjective condition to the fitness trainer in the club in the above-mentioned way.

In addition to the internal subjective monitoring of the workload, the respondents evaluated their current experience of psychological and physiological stress every morning via mobile message. For this purpose, a wellness questionnaire was used to assess physiological and psychological stress (25), in which participants rated the variables of sleep quality, fatigue, muscle fatigue, stress, and satisfaction on a Likert scale of 1-5 with the option of rating 0, 5. The participants of the experimental and control groups sent the evaluations of individual variables via mobile message to the fitness trainer employed at the club every morning after waking up, indicating the answer for the previous day. The total current state was defined by summing the results of all five questions. It is important to note that the markers of the athletes' current condition were monitored through the wellness questionnaire throughout the season, and the respondents were familiar with the procedure and method of assessment.

**Table 1. Experimental program during six weeks**

| Week | Number of exercises | Number of series | Complexity | Number of jumps |
|---|---|---|---|---|
| 1. | 12 | 34 | low | 240 |
| 2. | 12 | 31 | low | 223 |
| 3. | 12 | 25 | medium | 218 |
| 4. | 12 | 32 | medium | 278 |
| 5. | 12 | 31 | high | 258 |
| 6. | 12 | 33 | high | 298 |
| **Total** | **72** | **186** | **-** | **1.515** |

**Data Analysis.** The software STATISTICA for Windows version 13.4 (StatSoft, Inc., Tulsa OK) was used to process the results of the variables of the space of morphological characteristics, motor abilities, functional abilities, and the variables of subjective experience of the load of the participants. Descriptive statistics with arithmetic mean and standard deviation were calculated for all measured parameters. The normality of the distributions was tested with the Kolmogorov-Smirnov test. Non-parametric statistical tests (Friedmann ANOVA test and Mann Whitney U Test) were used for variables whose distribution deviated from normal.

The analysis for the variables in which the distributions were determined to be normal was the analysis of variance for repeated measurements (2x2 ANOVA), which was used to determine the analysis of differences between groups after the experimental program. The statistical significance of differences in all methods of data processing was set at the level of $p<0.05$.

## RESULTS

**The effects of additional plyometric training on the subjective experience of training load.** The Kolmogorov-Smirnov test determined that the results of three weeks out of the six-week experimental procedure deviated from the normal distribution. Analysis of differences in weeks for results deviating from a normal distribution will use non-parametric statistical processing using the Mann-Whitney U test, and for normally distributed results one-way ANOVA analysis of variance will be used (Table 2).

**Table 2. Kolmogorov-Smirnov test of normality of distribution**

| Week | Max D | K-S *p* | Critical value |
|---|---|---|---|
| 1 | 0.121 | p<0.20 | 0.233 |
| 2 | 0.183 | p>0.20 | 0.233 |
| 3 | 0.158 | p>0.20 | 0.233 |
| 4 | 0.216 | p<0.10 | 0.233 |
| 5 | 0.196 | p<0.15 | 0.233 |
| 6 | 0.130 | p>0.20 | 0.233 |

**The effects of additional plyometric training on the subjective experience of training load in the first week of the experimental procedure.** The results of the Mann-Whitney U test showed no significant differences between the experimental and control groups of participants in the subjective experience of the load from the first to the sixth week of the experimental procedure (Table 3).

The results of the Mann-Whitney U test showed significant differences between the experimental and control groups of participants in wellness in the first and second weeks of the experimental procedure, while no significant differences were found between the experimental and control groups of participants in wellness from the third to the sixth week of the experimental procedure (Table 4).

**Table 3. Differences between groups in the subjective feeling of burden for the six weeks**

| Week | U | Z | *p* |
|---|---|---|---|
| 1 | 103.00 | -1.170 | 0.241 |
| 2 | 0.053 | 0.001 | 0.816 |
| 3 | 0.512 | 0.016 | 0.480 |
| 4 | 132.00 | 0.126 | 0.899 |
| 5 | 131.00 | -0.126 | 0.871 |
| 6 | 0.223 | 0.006 | 0.645 |

**Table 4. Differences between groups in wellness for the six weeks**

| Week | U | Z | *p* |
|---|---|---|---|
| 1 | 51.50 | 3.025 | <0.005 |
| 2 | 6.35 | 0.169 | 0.017 |
| 3 | 2.54 | 0.757 | 0.121 |
| 4 | 85.00 | 1.819 | 0.065 |
| 5 | 92.50 | 1.548 | 0.121 |
| 6 | 2.55 | 0.076 | 0.120 |

## DISCUSSION

The results of this study showed that additional plyometric training does not significantly affect the subjective feeling of load during six weeks in the participants. The training design of the study itself was focused on additional plyometric training of low volume for 15 minutes, and high frequency, four times a week. The results show that this training program has a significant effect on some variables of fitness abilities without a significant difference in the results of the subjective feeling of load in both groups of participants. The practical contribution of this research can be seen in the context of the previous sentence, where it is evident that with a little time, additional plyometric training can influence the development of the motor skills of young football players without affecting their experience of the training itself. As values of the subjective sense of load are most often used as markers of training intensity, there is evidence that it can be used and be sensitive to some other external parameters of training load such as volume or duration (26). The results of this research support the research results of Foster et al. (24), who recorded the values of internal load parameters on a bicycle ergometer during training lasting 30, 60, and 90 minutes at an intensity of 90% of the anaerobic threshold of each subject. The authors of this research concluded that increasing the volume of training does not lead to a significant increase in the subjective feeling of load measured 30 minutes after training. Likewise, Green et al. (26) in their research

monitored the values of the subjective feeling of load after running training on a treadmill of different volumes. The participants ran for 20, 30, and 40 minutes at an intensity of 70% VO2max. The results showed that there were no significant differences in the parameters of the subjective feeling of load, however, a trend of increasing results was observed in the sections of the longer run. However, in contrast to the aforementioned studies, de Jesus et al. (27) tried to determine the impact of the duration of training with different intensities on the participants' subjective sense of workload. Based on the results, they concluded that the training volume can affect the subjective feeling of the load together with the intensity. The research of Fusco et al. (28) on young swimmers tried to determine whether the training volume affects the increase in the subjective feeling of training load. The results showed an increase in the value of sRPE in sections of swimming with the same intensity but with a higher volume, thus realizing that the training volume can be a factor that affects the change in the subjective experience of the load. Given that, according to the available information and this research, this is the first study that studies the connection and impact of plyometric training on internal load variables in football players, the results show that the volume and intensity of additional plyometric training did not significantly affect changes in the subjective feeling of load.

Also, this is the first study that studies the connection of plyometric training with the psychological and physiological experience of the load obtained through the wellness questionnaire. The results show that there are significant differences between the experimental and control groups in the first two weeks of the experimental procedure, while in the other four weeks, there are no statistically significant differences in the results. As the average scores of the questionnaire in the control group were significantly lower and the overall wellness of the young football players from this group during the first two weeks of the program was impaired, this can be explained by the matches played during the first two weeks of the experimental procedure. In the summary parameters during the six weeks of realization of the experimental procedure, it is evident that 4 competitive matches were realized during the first two weeks. Given that 44% of the participants of the control group participated in the first line-up during those matches, impaired wellness may be influenced by this factor. The results of this research and the decrease in the level of wellness during the first two weeks in the control group are also confirmed by the research of O'Connor et al. (29) and Morgan et al. (30) significant worsening of psychological and physiological stress experience ratings was recorded. Likewise, Hooper et al. (25) in their research observed an increase in the level of muscle fatigue during the competitive period in the period of increased training volume in elite swimmers. In the mentioned research, they realized that the accumulation of training load can lead to an increase in the perception of athletes in the context of muscle fatigue. Also, research by Moall et al. (31) showed a significant correlation between an increased volume of training days and a reduced level of wellness in elite football players over 16 weeks. Likewise, Thorpe et al. (32) noted in their research a significant correlation between the increased workload of one training day and the feeling of fatigue during the competitive period of top football players. Also, as in previous research, Buccheit et al. (33) found that using the feeling of psychological and physiological fatigue as well as heart rate variability, changes in the total training load during the preparatory period can be observed in top Australian football players.

## CONCLUSION

Considering the aim of the work, which was to determine whether plyometric training of high frequency and low volume has an impact on the subjective experience of training load, the results showed that the experimental group did not have a significantly increased experience of training load. If we consider the above, it can be concluded that plyometric training of high frequency and low volume can be an excellent training tool for young football players through which the abilities important for success in football can be developed. In addition, this type of training and these training modalities do not significantly affect the experience of training load measured through RPE and wellness questionnaires.

## APPLICABLE REMARKS

- The scientific contribution of this work is in favor of the fact that additional plyometric training lasting 15 minutes 4 times a week does not significantly affect the increase in RPE and wellness, therefore it can be

concluded that low-volume training that has an effect on increasing fitness abilities in football players will not significantly increase the experience of psychological and physiological stress. Daily monitoring of the subjective feeling of load is a good and important tool for controlling athletes. This especially applies to younger athletes because it is an extremely effective tool that is available to everyone and does not require financial expenses. Educated experts in the field of strength and conditioning of athletes can monitor and plan the activities of their athletes in a simple and effective way using RPE and wellness questionary.

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## AUTHORS' CONTRIBUTIONS

Study concept and design: Marin Dadic, Luka Milanovic. Acquisition of data: Ivan Belcic. Analysis and interpretation of data: Ivan Krakan. Drafting the manuscript: Marin Dadic, Ivan Belcic, Ivan Krakan. Critical revision of the manuscript for important intellectual content: Luka Milanovic. Statistical analysis: Mario Lovric. Administrative, technical, and material support: Mario Lovric. Study supervision: Marin Dadic, Luka Milanovic, Ivan Belcic.

## CONFLICT OF INTEREST

Authors declare no conflict of interest.

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