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Effect of Exercise Program for Injured Football Players: A Systematic Review and Meta-Analysis

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Abstract- This study aimed to investigate and analyze the effects of exercise programs for injured footballers on pain, muscle strength, range of motion, functional performance ability, and balance through a meta-analysis. To examine the effects of exercise programs on injury recovery and improvement in football players, a systematic literature review and meta-analysis, based on twenty-four papers published in Korea and other countries from the 2000s to the present, were conducted. The results of the meta-analysis are as follows. Overall, exercise was effective for football players with experience in getting injured. According to the results, while muscle strength, range of movement and functional performance would show statistically significant improvement, pain and balance would not. The findings on the individual sub-factors are as follows. First, according to the findings of the meta-analysis, the hypothesis that exercise programs applied to football players would influence pain could not be accepted, which means that exercise is not effective in relieving pain. Second, according to a meta-analysis, the hypothesis that exercise programs applied to football players would influence muscle strength was upheld, which means that exercise is effective in improving muscle strength. Third, according to the meta-analysis, the hypothesis that exercise programs applied to football players would influence the range of motion was upheld, which means that exercise is effective in improving the range of motion. Fourth, according to a meta-analysis, the hypothesis that exercise programs applied to football players would affect functional performance was upheld, which means that exercise programs are effective in improving performance ability. Fifth, according to the meta-analysis, the hypothesis that exercise programs applied to football players would influence balance ability was not significant, which means that exercise is not effective for improving balance.

Keywords*: football player injury; exercise program; pain; muscle strength; range of motion; functional performance; balance; meta-analysis.*

1. Introduction

Football is the most popular sport in the world; according to the report of the International Football Federation, approximately 270 million players are active as athletes [1]. Apart from this popularity and interest, football has been associated with the most injuries as a sport [2].

Injuries and re-injuries are frequent in football players. For instance, there is a high probability of ankle re-injury within a year after the first ankle injury occurs [3]. After treatment, the injured football players undergo a separate rehabilitation exercise program to recover their impaired function. Its purpose is to restore the ankle to allow reengagement in sporting activities. The average duration for football players to return after injury is 61 days for severe ankle injuries and 28 days for moderate injuries [3]. Various studies have been conducted on the practical effects of exercise programs for football players after injuries, and unfavorable effects have been reported [4,5].

Injuries of football players lead to an increase in pain, as well as a decrease in muscle strength, range of motion, functional performance, and balance. Therefore, studies have analyzed the effects of exercise programs conducted after injuries of football players on pain, muscle strength, range of motion, functional performance, and balance. These studies analyzed the effectiveness of the program by measuring the effect size or the magnitude of each variable before and after the exercise program to evaluate the degree of change [6-8].

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These studies attempted to analyze how the exercise program affected pain in specific injured areas. In this regard, the effect on each damaged area and the effect of each variable are meaningful results. Nevertheless, a comprehensive analysis and evaluation of exercise programs by synthesizing previous studies should be conducted. Comparing and analyzing the reports of these studies will provide a basis for determining more effective exercise programs. In this respect, it is necessary to analyze and evaluate exercise programs applied to football players by body part and by effect variables through a meta-analysis, as in this study.

I aim to identify and analyze the effects of athletic programs conducted after the injuries of professional football players and youth football players in various countries. For this purpose, It will analyze and evaluate the effect of the intervention programs for rehabilitation by effect variables, injured domains, and programs. Thus, the effect of the intervention program on each effect variable and damaged area is verified, and finally, the overall effect of each program is analyzed. Therefore, we intend to provide basic data on effective athletic programs. For this purpose, this study adopts a meta-research method that synthesizes and analyzes existing studies without composing a new experimental study. Studies have already been conducted on the subject of this study in various countries, and they provide meaningful results. However, these studies have different samples and different exercise programs, so there is some heterogeneity between studies. Because of the heterogeneity of the studies, various effect sizes and uncertainties exist. This study intends to calculate the effect size as a single, quantified numerical value while verifying possible such uncertainties. Therefore, a meta-research that comprehensively analyzes these studies will derive more practical results on the effectiveness of exercise programs. In this respect, the analysis and evaluation of the effect through a meta-research that comprehensively analyzes existing studies is important for researching and establishing more advanced exercise programs.

For the purpose of this study, the research questions were established as follows: Does each exercise program bring statistically significant results on pain, muscle strength, range of motion, functional performance, and balance of football players? Does each exercise program bring statistically significant results to the injured area of football players? Does each exercise program bring statistically significant results to the recovery of football players?

As in this study, providing a single effect size by synthesizing the results of several studies performed on each variable helps to implement a more validated intervention program. Recovering from injury and returning to normal activities through an intervention program would be a desirable goal for football players and the general public alike. For this goal, it is essential to provide a validated intervention program through estimation of effect sizes.

2. Materials and Methods

2.1 Data sets

Five data sets of TM proteins are examined in this study (see Table 1). These contain Pain effect data, Muscle strength effect data, Functional performance effect data, balance effect data, ROM effect data. The data are extracted from Korean Studies Information Service System (KISS) database of KoreaMed, DBpia, Korea Education & Research Information Service (KERIS), and Korean Studies Information.

Table 1. Data sets examined

Kinds of Effect	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value Upper limit	P-value
Pain	29	-0.20647	0.577993	0.334075	-1.33931	0.926375	-0.35722	0.720928
Muscle strength	101	0.465814	0.110819	1.23E-02	0.248613	0.683015	4.203386	2.63E-05
Functional performance	116	0.635294	5.60E-02	3.14E-03	0.525488	0.745	11.33956	0
balance	8	-0.81064	0.341837	0.116852	-1.48063	-0.14065	-2.37142	1.77E-02
ROM	26	0.783897	9.91E-02	9.82E-03	0.589654	0.97814	7.90973	2.66E-15
Total	304	0.608873	4.41E-02	1.95E-03	0.522371	0.695375	13.79592	0

2.2 Selection procedure

2.1.1. Selection of literatures

For our purpose academic journal articles published in various countries including Korea between 2000 and 2020 were analyzed. Prior to analysis the literature review was conducted according to the guidelines in the systematic literature review handbook on the intervention method of the Cochrane collaboration and

the systematic literature review and the current review employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) procedure [9]{Page, 2021 #27}. This review was approved by in the Gachon university ethics committee(1044396-202203-HR-049-01), and no protocol was published for this systematic review.

A literature search was conducted using the Korean Studies Information Service System (KISS) database of KoreaMed, DBpia, Korea Education & Research Information Service (KERIS), and Korean Studies Information (KSI). These include the literatures written in the Korean languages. The foreign literature search, using PubMed, MEDLINE, ClinicalKey, Science Direct, and Web of Science, was limited to academic journals published within the last 20 years and domestic doctoral research papers. For studies published between January 2000 and August 2020, the final search was conducted on September 1, 2020. The following search terms were used: “Football,” “Football,” “Rehabilitation,” “Injury,” and “Exercise.” The entire process of data collection and selection was independently reviewed and carried out by the researcher and related experts according to the aforementioned selection exclusion criteria, and the degree of agreement of the evaluators was confirmed using Cohen's k. If the evaluators disagreed, they reviewed their findings until a consensus was reached, followed by a review by a professor in the Department of Physical Therapy. In addition, the entire process, including data extraction and systematic confirmation, approval, synthesis, statistical merging, and result reporting, for the selected research was conducted based on a systematic review and meta-analysis by the National Evidence-Based Healthcare Collaborating Agency.

The search yielded 34,456 studies published between 2000 and 2020. This included 175 studies from DBpia, 63 from KoreaMed, 16 from Korean Academic Information, 16 from the Korea Education and Research Information Service 101, 9,116 from PubMed, 8,250 from Medline Complete, 726 from ClinicalKey, 1,744 from ScienceDirect, and 14,265 from the Web of Science. During the first selection process, 34,219 studies were excluded after the review of their titles and abstracts of the study, and 35 studies were duplicated. For the second selection of only studies on the effectiveness of exercise programs, the aforementioned selection and exclusion criteria were used. As a result, there were 26 studies without the original text and 38 studies without the design of a randomized clinical trial. A total of 178 studies were excluded, including 23 studies on interventions other than the prescribed exercise program, 18 studies on non-elite football players, 58 studies without appropriate medical results, 3 doctoral dissertations and 15 other studies. Finally, 6 Korean studies and 15 overseas studies, making a total of 21 studies, were included for the analysis. The criteria for exclusion in literature selection are briefly summarized as follows: Duplicated articles, Articles without full-text, Articles out of scope(Studies not on the effectiveness of exercise programs, studies with interventions other than the prescribed exercise program, studies with subjects other than elite soccer players, studies not reporting appropriate medical results), Articles with insufficient details and Articles with limited rigor. The results of literature analysis can be summarized as Figure 1

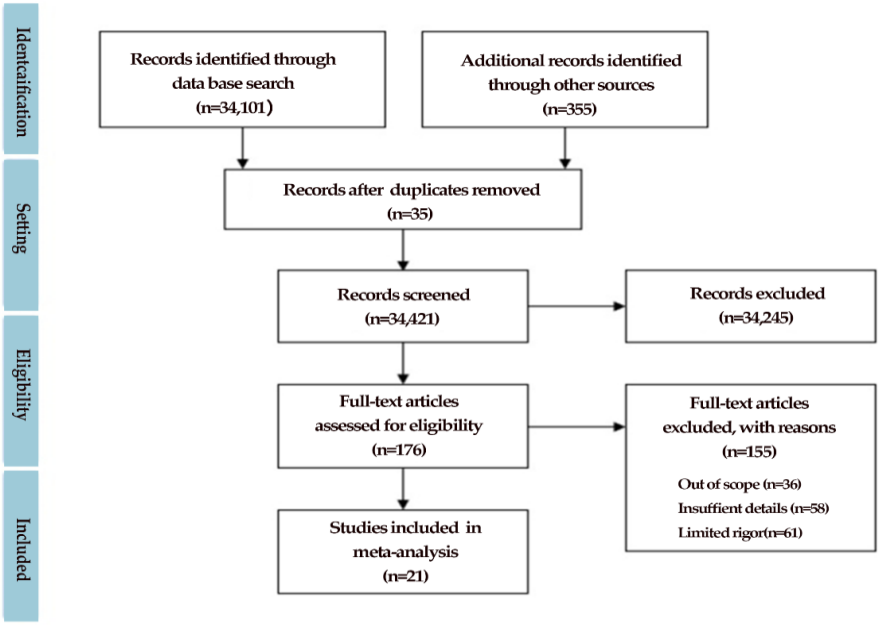

Figure 1- Flow chart of the study

2.1.2. Selection of Study categories

As a result of the systematic literature review, it was found that exercise programs applied to football players affected the variables specified as follows; pain, muscle strength, range of motion, functional performance, and balance. To verify the impact, meta-analysis was

conducted. A meta-analysis of 21 previous studies on pain, muscle strength, range of motion, functional performance, and balance, as dependent variables, were conducted. Therefore, the main purpose of this study was established as investigating the size of the effect of exercise programs for football players after injuries on pain, muscle strength, range of motion, functional performance, and balance.

In order to analyze the effect of the intervention programs, I analyzed the effect size according to the variables of effect, the damaged area, the type of exercise program, and age, respectively. The variables of effects set in this study are Pain, Muscle strength, ROM, Functional performance, and Balance, and the damaged areas are Muscle, Knee, Ankle, and the ages are youth and adults. And the exercise programs are as follows. The intervention programs analyzed in this study are classified according to the program purpose. The first is physical training for strengthening muscle strength, the second is plyometric exercise to improve functional performance, and the third is an auxiliary program to promote the exercise program.as electrotherapy for the purpose of pain relief and symptom relief, and finally other exercise programs with the purpose of complex effects. The others include fascia manipulation program, aerobic fitness program, ankle protector and adhesive tape application, treadmill running, balance training program

2.3 Effect size analysis and Homogeneity test

As a result of the systematic literature review, it was found that exercise programs applied to football players affected the variables specified as follows; pain, muscle strength, range of motion, functional performance, and balance. To verify the impact, meta-analysis was conducted. A meta-analysis of 21 previous studies on pain, muscle strength, range of motion, functional performance, and balance, as dependent variables, were conducted. Therefore, the main purpose of this study was established as investigating the size of the effect of exercise programs for football players after injuries on pain, muscle strength, range of motion, functional performance, and balance.

Table 2. Test results for the homogeneity of sampling

N	Q	p	I2
280	3864.94	.000***	92.78

N: number of effect sizes, Q; homogeneity test statistic, p; significance level for the homogeneity test statistic, I2; actual variance ratio, ***; p <.001

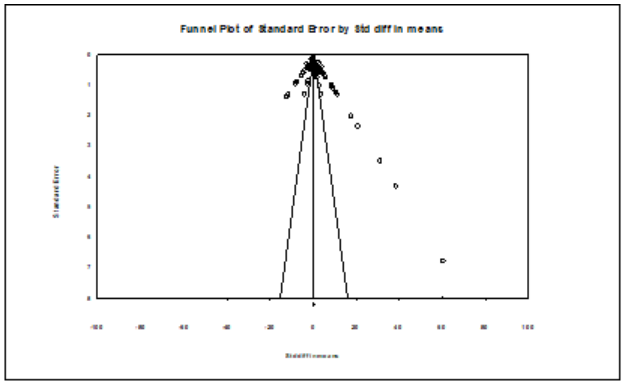

Figure 2- Funnel plot

3.Results and Discussion

3.1 Publication Bias

A funnel plot of the effect size on the x-axis and the standard error on the y-axis was used to demonstrate the overall distribution of the effect sizes targeted for analysis in this study (Figure 1). On examining the funnel plot, one-third of the research results were gathered around the average effect size, but several were distributed to the left and the right. In the case of no publication convenience, the studies were distributed symmetrically around the combined effect size, but in the case of publication convenience, they were concentrated on one side. The distribution is interpreted to be asymmetrical, with the effect sizes spread to a little right direction and the center of the main axis on a similar scale, rather than being concentrated on either side evenly (Figure 2).

3.2 Risk of Bias

The selected 21 studies were evaluated for quality using the Cochrane RoB tool. Eleven papers (52.4%) were evaluated as uncertain for “random allocation order generation,” and 12 (57.2%) papers were evaluated as uncertain for “Allocation Order Concealment.” It was evaluated as 'uncertainty of the risk of bias. Fifteen papers (62.0%) were judged to have uncertain implementation bias, and more than half were determined to have uncertain risk of bias. Four articles (19.1%) were determined to have uncertain confirmation bias, and an overall low risk was found. Three papers (14.3%) had uncertain bias for dropout; overall, the risk was low. Four articles (19.1%) had uncertain reporting bias; the risk of reporting bias was determined to be generally low. Six papers (28.6%) demonstrated uncertainty for other biases, and they were generally considered to have a low risk of bias (Figure 3).

Table 4. Effect sizes of the research results

Category	N	The mean effect size (D)	95% CI	P
Kinds of Effect				
Pain	29	-0.19	-1.36 ~ 0.99	.752
Muscle strength	101	0.68	0.57 ~ 0.79	.000***
ROM	26	0.77	0.60 ~ 0.95	.0000***
Functional performance	116	0.58	0.36 ~ 0.81	.0000***
Balance	8	-1.00	-1.77 ~ -0.24	.011*
Damaged area				
Muscle	33	0.26	-0.01 ~ 0.52	0.055
Knee	70	-0.05	-0.30 ~ 0.19	0.654
Ankle	37	0.93	0.84 ~ 1.03	0.000***
Complex	140	0.95	0.66 ~ 1.25	0.000***
Type of exercise program				
Physical exercise	111	0.57	0.43 ~ 0.72	0.000***
Electrotherapy	2	-0.46	-0.97 ~ 0.06	0.085
Plyometric exercise	13	0.42	0.07 ~ 0.77	0.019*
Others	154	0.70	0.42 ~ 0.97	0.000***
Age group				
Adult	211	0.59	0.42 ~ 0.78	0.000***
Youth	69	0.61	0.47 ~ 0.75	0.000***

*** P < .001, * P < .05

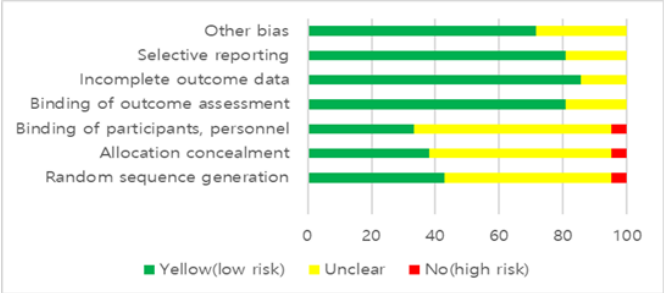

Figure 3. Assessment of risk of bias in selected studies

3.3 Effect size of exercise program in football players

The homogeneity analysis showed that the studies were heterogeneous, and the effect size analysis was performed using a random-effects model. The average of the 280 effect sizes obtained from the 21 papers selected in this study was 0.57, as measured by the random-effects model. The 95% confidence intervals ranged from 0.43-0 (p<.001). The results of the meta-analysis were statistically significant, and the research hypothesis was adopted (p<.001) (Table 3). Because we synthesized the results of previous studies through a meta-analysis, the degree of reporting that exercise programs improve the conditions of football players is high, but some studies reported that it was not effective. The overall result was found to be significant because it did not contain. It can be interpreted that the exercise program improves the condition of football players.

Table 3. Total effect size by random-effects model

N	The mean effect size (D)	95% CI	P-value
280	0.57	0.43~0.71	.000***

*** P < .001

3.4 Distribution of effect size of detailed research results

The effect sizes for each outcome variable of the exercise programs applied to football players were as shown on the Table 4.

I investigated key factors related to the effectiveness of exercise programs. My study evaluated the effects of an exercise program applied to football players on pain, muscle strength, range of motion, functional performance, and balance. As a result, in this study, each effect size was calculated as one quantified numerical value for effect variables, damage area, programs applied, and age. Significant items were shown by evaluating whether the calculation results were statistically significant. Thus, the effects of the applied programs on the effect variables were evaluated.

First, the size of the pain improvement effect was -0.19, which showed a very small effect size. Although pain appeared to decrease slightly after the application of

programs when comparing before program application, this effect size was not statistically significant. Because the lower limit is -1.36, the upper limit is 0.99, and the 95% CI interval includes 0, so this value is evaluated as not statistically significant. However, in the study of Yoon et al. [14], the pain scale decreased from 51.25± 15.75 to 15.63 ± 15.45. In this study, the average value of the pain scale was 35.63 ± 10.84, and the effect of the exercise program on pain was statistically significant. This is because the results shown in the study of Yoon et al. [14] are the results of applying a single rehabilitation program, whereas this study is a synthesis of heterogeneous studies. From this point of view, it can be seen that the selection of the application program is important for the improvement of pain relief. In order to know which program is effective, meta-analysis for each exercise program must be performed to evaluate the effect size of each program in detail.

The effect size of muscle strength enhancing was 0.68, which can be interpreted as statistically significant. The exercise program improved the muscle strength of the football players. The improvement in muscle strength was shown in terms of improvement of isokinetic muscle function (Almeida et al. [15]) and improvement of thigh strength and muscle circumference (Tarada et al. [3]). Almeida et al. [15] applied an aerobic exercise program, and Tarada et al. [3] applied neuromuscular electrical stimulation (NMES). Similar results were also found in the study of Park and Kim[16]. This study analyzed the degree of improvement in muscle strength by applying an exercise rehabilitation program. According to the results of this study, extensor strength of repaired knee was significantly improved at the peak torque (60°/sec, 180°/sec) ($p<.001$) and the peak torque per body weight (60°/sec, 180°/sec) ($p<.001$) and total work (60°/sec, 180°/sec) ($p<.001$). Contrary to the research results in which aerobics and NMES exerted an effect on the improvement of muscle strength, the results of using other, the data of which was not included in this study, were divergent. Kang et al. [17] showed that there was no significant difference in muscle strength before and after application of Kinesio taping for both men and women, but Fereydounnia et al. [18] showed that the application of Kinesio taping had a limited effect on muscle strength. It means that this positive effect was only seen in the average extensor strength of the ankle. These results were similar to the results of the study conducted by G. H. Yun and M. D. Huh [19], who reported that the isokinetic exercise program did not show statistically significant effects based on the measurements of the flexors and extensors in the affected thigh even though a statistically significant effect has been reported at an exercise load of 60/sec. According to my findings, among exercise programs, aerobics and NMES might have effects on the improvement of muscles in terms of isokinetic muscle function and thigh strength and muscle circumference

It depends on the exercise programs whether exercise programs have statistically significant differences in improving the range of motion of joints or not. I found there were statistically significant differences between the groups both before and after the comparison. And also Kim and Jeon[20] studying the impacts of physical exercise showed statistically significant effects within the exercise group for the inversion and eversion of the affected side and the inversion of the non-affected side. However, no significant results were found in the other study that applied the auxiliary program. Brandolini et al [21], who studied the improvement effect of fascial manipulation (fascial manipulation, FM), reported that the application of FM does not have a significant effect on the improvement of the joint range of motion. In another study applying the auxiliary program which was conducted by Taradaj[3], the effect of Kinesio taping did not result any significant difference on the effect on the range of motion of the joint, From these results, it can be inferred that the effects of the auxiliary programs such as Kinesio taping and the program aimed at the fascia do not significantly improve the range of motion of the joint while physical exercise can improve ROM.

I also found that the effect of exercise programs on functional performance was positive. It means that exercise programs can make improvements in the functional performance of football players. These results are similar to those of the studies by Chtara et al. [5] on the effect of a 6-week exercise program, Nambi et al. [2] on the isokinetic exercise effect, and Pedersen et al. [22] on the correlation between maximal muscle strength and functional performance. Brandolini et al. [21], who studied the effect of fascia adjustment, reported statistically significant difference in improving the functional performance. In addition, Bianchi et a.l [23] and Beato et al.[24] investigated respectively whether there were the statistically significant differences in functional performance between the group that performed only COD (Change of direction) training and the group that received both COD training and plyometric training. Both reported that the rehabilitation exercise program has an improvement effect in terms of functional performance. Otherwise, in the study of van de Hoef et al[25] who conducted a study on whether bounding exercise would affect the re-injury rate by increasing functional performance, no statistically significant results were found. Nevertheless, it is not known whether the somewhat conflicting results in this study and other studies are due to differences in the injured areas or differences in training programs. Therefore, a separate study will need to be conducted to confirm these results.

This study showed a negative effect size on balance,

which means it is difficult to interpret that the balance was improved, as the effect size was found as negative effect. However, Gioftsidou et al. [26] reported training programs improved balance. Hrysomallis's [27] conducted to determine whether there is a difference in balance with and without ankle injuries for Australian football players , who have more ankle injuries than Australian players in other sports and football players in other countries. The research showed that there was no difference in balance in the two groups. These results would suggest that the ankle's balance needs considerable time for recovery. Hrysomallis's [27]'s study limited on the ankle, but considering the importance of the ankle during balancing, it can be considered that facilitating natural recovery over time is more effective for restoring balance after injury than the exercise program.

I also conducted a meta-analysis for each damaged area. Summarizing the results, ankle injury showed a significant effect size. However, no such results were found for the knee area. Consistent with the outcomes of this study, a study by Kim and Shin [28] investigated the effect of the ankle protector and adhesive tape on the balance and showed a significant improvement in the range of motion of the ankle. Similar results were reported by Yun et al. [19]. They analyzed the difference in the maximum rotational force of the ankle after the rehabilitation exercise program was administered for 12 weeks, and reported that the rehabilitation program resulted a remarkable improvement. Similar result was also found in the study of Zouita et al.[29]. It performed proprioceptive exercises rehabilitation for 8 weeks to investigate the effects of proprioceptive exercise rehabilitation on isokinetic strength and postural balance in athletes with ankle sprains. As a result, it was concluded that the unstable upper ankle can be effectively stabilized through post-muscle and posture control. However, Zouita et al. [29] did not evaluate whether 8 weeks achieved maximum effect. In addition, it presents a limitation in that it is not known how long this effect will continue over time.

Contrary to the ankle area, I found that there was no statistically significant improvement in the knee area. Similar to my results, in the study of Hong et al.[30] who studied the effect of exercise program application on male football players after meniscal cartilage resection, it was found that knee extension muscle strength on both the affected and unaffected sides showed statistically significant differences after exercise rehabilitation in the improvement of maximum rotational force, rotational force per body weight, and total work.

I found that the exercise programs including the plyometric exercise program had a statistically significant effect size on the recovery of injured soccer players. For the exercise programs, these results were consistent across all the studies analyzed. The results of my study related to the plyometric exercise program were also reported by Bianchi et al.[23], who studied whether the plyometric exercise program has a significant effect on the ability to perform a long-distance jump, triple jump, and 505 change of direction (COD). Their study assessed both groups that participated in the weak and strong plyometric exercise programs respectively, and the results showed that both facilitated significant improvements. Similar results were found in the study of Beato et al.[24] which analyzed the effect of applying the plyometric training program to the COD training program. In the study of Beato et al.[24] there were significant effects in terms of strength and speed ability in the both cases of only COD training performed and the plyometric training program performed with the COD training, of which the latter showed a greater improvement effect.

When looking at the results of this study by age, the effect size was larger in adolescents(in the age 0f 14-19) than in adults. This means that rehabilitation programs in adolescents show better outcomes. However, the effect size for children is 0.61 and for adults is 0.59, so it can be said that the overall effect of the rehabilitation program is large regardless of age. This result is consistent with the overall mean effect size of 0.57 in this study. The result of this study that the rehabilitation program for adolescents is good is consistent with the results of other individual studies on adolescents. Similar result was obtained by Celebrini et al.[31]. They investigated whether a novel movement strategy incorporated within a football warm can affect the biomechanical risk factors, as a result, ACL injury in female football players of 14-16 years old. For this purpose, they tried to find whether a statistically significant difference occurs when the Core Position and Control movement strategy (Core-PAC) warm-up are performed before regular football training. As a result, it was found that the peak flexion angle of football players was increased after performing the program for 6 weeks. Chtara et al.[4] showed that elite young male football players' physical performances could be significantly and specifically improved after plyometric training over short-term in-season training. In summary, it can be said that the post-injury exercise program has a statistically significant effect regardless of age, but it can be said that the effect is greater in adolescents in the growth stage than in adults.

Although this study was trying to fulfill the research objectives, it has limitations as follows; first, in spite of maximizing the meaning of meta-analysis, many papers collected during the research process were excluded because of not fulfilling the data requirements and mathematical data not described. In this respect, since the results of this study are based on certain data, the

factor of intervention programs such as duration, frequency, and volume were not to be analyzed in details, which will be limitations in applying them to the rehabilitation field.

Second, there is a limitation that most of the studies analyzed were conducted on male athletes. The physical differences between women and men produce differences in the form of injuries and above all, different results in terms of rehabilitation. Therefore, a separate meta-analysis synthesizing the results of studies on female football players' injuries and exercise programs should be attempted. This analysis will have the meaning of producing basic data for the development of a more suitable exercise program for female athletes. Summarizing the results of this study, exercise programs significantly improved muscle strength, range of motion, and functional performance, but not pain and balance. It was found that the improvement effect of the ankle was significant for each injured area, which is particularly meaningful for football players with frequent ankle injuries. The exercise program, including the plyometric exercise program, was also found to have a significant effect, and the exercise program may be necessary for the recovery after the injury of the football player. The Effect on youth is larger than that on adults. The exercise program is appropriate and necessary after the injury of a professional sports player. This result can be applied to the general public, and training and guidance on exercise programs after certain treatments after injury in front-line hospitals are required.

4. Acknowledgments

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