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original article

The effect of "FIFA 11+" on vertical jump performance in soccer players

O efeito do "FIFA 11+" na performance de saltos verticais em atletas de futebol

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Abstract – The aim of this study was to evaluate the effect of 9 weeks of the "FIFA 11+" warm-up program on vertical jump performance in soccer players. The study included 20 athletes of the Under-20 category from a Brazilian championship serie A team (age: 18.3±1.6 years; years of training: 8.2±1.3; body weight: 74.0±7.1 kg, height: 177.8±6.5 cm, and fat percentage: 10.7±1.9%), divided into an intervention group (G11+; n=10) and a control group (CG; n=10). The athletes were evaluated before and after the intervention regarding countermovement jump (CMJ) and squat jump (SJ) performed on a force platform. The maximum jump height was considered for data analysis. A mixed-model ANOVA was used to verify the main time vs. group effects. Both groups underwent the same training routine (physical, technical, and tactical) and only differed in terms of the proposed warm-up, which was performed three times per week in G11+. No significant difference in jump performance was observed in CG, while G11+ showed significant improvement in both types of jumps (CMJ: F=26.23, p<0.01; %change=11.3; SJ: F=23.16, p<0.01, %change=9.8). In conclusion, 9 weeks of intervention with the "FIFA 11+" warm-up program during routine training promoted significant improvement in jump performance.

Key words: Athlete; Intervention; Sport performance.

Resumo – *O objetivo do estudo foi verificar o efeito do treinamento de nove semanas de um programa de aquecimento "FIFA 11+" na performance de saltos verticais (SV) de jogadores de futebol. Participaram do estudo 20 atletas da categoria sub-20 de uma equipe da série A do campeonato brasileiro (idade: 18,3 ± 1,6 anos; tempo de prática 8,2 ± 1,3 anos; massa corporal de 74,0 ± 7,1 kg; estatura 177,8 ± 6,5 cm e percentual de gordura 10,7 ± 1,9 %), separados em grupo intervenção (G11+; n=10) e grupo controle (GC; n=10). Os Atletas foram avaliados antes (Pré) e após (Pós) a intervenção por meio dos saltos Countermoviment Jump (CMJ) e Squat Jump (SJ), realizados em uma plataforma de força, sendo os valores máximos da altura dos saltos adotados para análise. Foi realizada uma ANOVA modelo-misto para verificar os possíveis efeitos tempo x grupo. Nível de significância adotado de p < 0,05. Ambos os grupos foram submetidos à mesma rotina de treinamento (físico, técnico e tático), diferindo apenas o aquecimento proposto, que foi realizado três vezes por semana para o G11+. O GC não apresentou alteração significativa na performance dos saltos, porém o G11+ apresentou melhora significativa para ambos os tipos de saltos (CMJ: F= 26,23, p<0,01; %mudança= 11,3; SJ: F= 23,16, p<0,01, %mudança= 9,8). Desta forma, as nove semanas de intervenção com o programa de aquecimento "FIFA 11+" na rotina de treinamento promoveu um aumento significativo no desempenho dos saltos.*

Palavras-chave: *Atleta; Desempenho esportivo; Estudo de intervenção; Futebol.*

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INTRODUCTION

The "FIFA 11+" warm-up program was developed by the FIFA Medical Assessment and Research Centre (F-MARC). The main aim of the program is the prevention of the most common injuries in soccer, i.e., ankle and knee sprains and muscle strains, through dynamic and specific exercises[1-3]. The efficacy of "FIFA 11+" in injury prevention has been demonstrated[4-6], and its developers classify it as a complete warm-up program since it combines cardiovascular activation and preventive neuromuscular exercises[4,7]. The key element of the program is the promotion of appropriate neuromuscular control during exercise, ensuring good posture and body control (including correct alignment of the joints – hip, knee, and ankle)[4].

Controversy still exists in the literature regarding the efficacy of "FIFA 11+" in improving performance in neuromuscular tests and the athletic performance of soccer players. In this respect, the program has been described to improve neuromuscular control, but without influencing performance in specific physical tests[1,9,10]. However, other studies indicate improvement in neuromuscular performance tests, such as isokinetic strength, vertical jumps, and agility[2,3,10]. There are an increasing number of studies investigating the influence of a warm-up routine on neuromuscular performance in specific tests, considering that structured warm-up activities can improve physical performance. According to Fardkin et al.[11], 79% of the studies on this topic reported improvement in jump height, sprint time and ball control skills, while only 3% of the studies did not identify any alteration.

Although soccer is a predominantly aerobic sport, the anaerobic fitness seen in muscle power actions is related to decisive activities during a game, such as sprints, jumps, kicks, and tackles[12,13]. Short sprints (< 20 m) are the most common actions performed by soccer players during a game[14], which are associated with countermovement jump (CMJ) performance[15]. This suggests that the performance in high-intensity exercises depends on the level of muscle power, i.e., the ability of neural recruitment, utilization of the stretch-shortening cycle (SSC), and the rate of anaerobic energy release[16].

High-intensity actions that precede decisive moments in a game (sprints, kicks, and vertical jumps) are key elements for the performance of soccer players[12]. Therefore, the objective of the present study was to evaluate the effect of 9 weeks of intervention with the "FIFA 11+" program on neuromuscular parameters (strength and power) of soccer players. The hypothesis of this study was that the intervention group (G11+) would exhibit improvement in vertical jump performance since the development of strength, joint stability, and adequate neuromuscular control of the lower limbs are the objectives of the "FIFA 11+" program.

METHODOLOGICAL PROCEDURES

Subjects

Intentional non-probabilistic sampling was used to select 20 soccer play-

ers of the Under-20 category from a professional club in the city of Florianópolis, Santa Catarina, Brazil. The athletes were randomly divided into two groups: an intervention group (G11+, n=10) and a control group (CG, n=10). Criteria for inclusion in the study were at least 5 years of previous training, absence of any type of muscular-articular injury, and participation in at least 85% of the training sessions. Three of the 20 subjects were excluded from the analysis because they did not meet the third criterion (i.e., participation in at least 85% of the sessions). Thus, 17 athletes [G11+ (n = 9) and CG (n = 8)] completed the study period (age: 18.3 ± 1.6 years; years of training: 8.2 ± 1.3; body weight: 74.0 ± 7.1 kg; height: 177.8 ± 6.5 cm, and fat percentage: 10.7 ± 1.9 %). The goalkeepers did not participate in the study because of the different demands imposed by the specific training to which they are submitted.

Prior to data collection, the subjects received information about the objectives and methods of the study and signed the free informed consent form. The study was approved by the Ethics Committee on Research Involving Humans of Universidade Federal de Santa Catarina (Protocol No. 724.427) and was conducted in accordance with the Declaration of Helsinki.

Control group (CG)

The athletes maintained the normal warm-up routine of the club, matching its duration to that of the "FIFA 11+" (20 minutes). The warm-up activities that differed between groups consisted basically of technical ball exercises, mini-games, and combined running and stretching exercises. The criterion for continuation in the study was the participation in at least 85% of the training sessions.

"FIFA 11+" group (G11+)

The athletes underwent the "FIFA 11+" program three times per week for 9 weeks during the pre-competition period. The level of difficulty was increased every 3 weeks and all athletes progressed together to the next level as suggested by the manual of the program[7] (week 1 to 3, level 1; week 4 to 6, level 2; week 7 to 9, level 3). The criterion for continuation in the study was the participation in at least 85% of the intervention proposed (23 sessions).

The two groups had a similar routine of physical, technical and tactical training, with the only difference being the warm-up of G11+ on the days of intervention. The total number of training sessions during the study period was 81, corresponding to 7,290 minutes. The time destined for the intervention was 540 minutes (7.5%) as shown in Table 1.

Intervention program

The "FIFA 11+" program takes an average 20 minutes to complete and consists of three parts: (i) running exercises at a low speed, intercalated with active stretching and partner contact; (ii) six different sets of exercises, including strength, plyometrics and balance, each with three levels of increasing difficulty; (iii) running exercises at moderate speed combined

with specific soccer movement, with constant change of direction. All 27 exercises focus on core stability, neuromuscular control, agility, and eccentric hamstring strength (Box 1).

Table 1. Description of the training sessions during the intervention period

Games	Total time (min)	% Training time
Exhibition	300	4.1
Official	360	5.0
Training description		
Warm-up (intervention)	540	7.5
General warm-up	360	5.0
Technical-tactical training	1125	15.4
Small-sided games	1260	17.2
Aerobic capacity	375	5.5
Power	400	5.5
Plyometric training	260	3.5
Strength training (weight training)	2310	31.7
Total	7,290	100.0

Box 1. Exercises proposed by the "FIFA 11+" warm-up program.

Exercises	Duration
Part 1: Running exercises: straight ahead; hip adduction; hip abduction; circling partner; jumping with shoulder contact; quick forward and backward running (2 repetitions).	8 min
Part 2: Strength, Plyometrics and Balance	10 min
Bench: frontal static; alternate leg lifting; lifting and holding one leg (3 repetitions of 30 seconds per side).	
Hamstring: beginner (3-5 repetitions); intermediate (7-10 repetitions); advanced (12-15 repetitions).	
Single-leg stance: holding the ball; throwing ball to the partner; testing the partner's balance (2 repetitions of 30 seconds).	
Squats: squat with toe raising; squat with forward lunge; one-leg squat (2 repetitions of 30 seconds).	
Jumping: vertical jumps; lateral jumps; box jumps (2 repetitions of 30 seconds)	
Part 3: **Running exercises**: sprinting ahead; with single-leg jump; with change in direction (2 repetitions).	2 min

Testing procedure

The athletes were evaluated at two time points: before (pre) and after (post) 9 weeks of the intervention (Figure 1). Prior to data collection, the athletes performed a short stretching and warm-up of the lower limbs, followed by specific training of the CMJ and squat jump (SJ) technique to standardize the protocol. This training consisted of four to five CMJ and SJ at intervals of approximately 1 minute. The number of jumps depended on the individual movement technique of each subject. Next, the athletes performed three attempts of CMJ, followed by three attempts of SJ, at a recovery interval of 2 minutes between jumps. The jumps were performed on a piezoelectric

force platform (Quattro Jump, 9290AD, Kistler®, Winterthur, Switzerland) and the maximum jump height was selected for analysis of the data. The data acquired were transmitted via a cable to a computer at a frequency of 500 Hz.

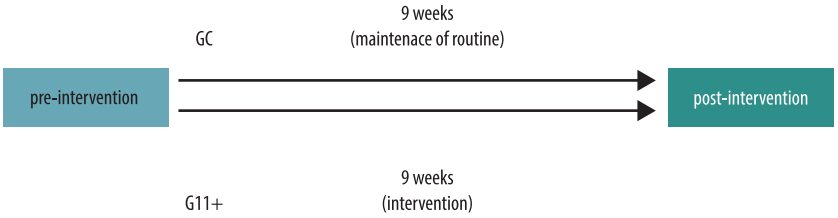

Figure 1. Experimental design.

Jump height was calculated with the Quattro Jump software by double integration. The instantaneous velocity was calculated from the strength values obtained with the platform, body weight of the subject, and known initial velocity. The variation in velocity needs to be known to obtain jump height, i.e., the impulse generated during the propulsive phase of the jump according to the following equation:

$$h = \text{int}(V(t)\text{-}V0)dt$$

where h = jump height; V = final velocity; $V0$ = initial velocity, and dt = time interval.

A pattern was maintained for execution of the jumps, which was monitored by an experienced examiner. In the case of CMJ, the athlete started from a static standing position, hands on the hips, with the jump being preceded by a countermovement that consisted of a downward acceleration of the center of gravity, flexing the knees to near 90º. This angle was observed and visually controlled by the examiner. During the jump, the trunk was maintained in a near vertical position and the subject was instructed to jump as fast as he could at the largest height possible. In this protocol, the quadriceps muscles are stretched during the descending (eccentric) phase, wherein the elastic structures are elongated, causing accumulation of elastic energy that can be reused during the ascending (concentric) phase[11,12]. In SJ, the athlete jumped from a static position with the knee angle at approximately 90º, the trunk in a near vertical position, and the hands on the hips. The jump was performed without countermovement, so that only the concentric action of the muscles occurred during the movement.

Statistical analysis

Descriptive statistics (mean and standard deviation) was used for presentation of the data. The normality of residuals was verified by the Shapiro-Wilk test ($n<50$). A mixed-model ANOVA was used for analysis of the data. When significant differences were detected, the Bonferroni post-hoc test was applied. A level of significance of 5% was adopted for all tests. Statistical analysis was performed using the SPPS 17.0 software.

The effect size was calculated using the method proposed by Choen[17]

by subtracting the pre-test mean from the post-test mean and dividing the difference by the pooled standard deviation. The effect size was classified according to the following criteria: < 0.1 trivial; 0.1-0.3 = trivial/small; 0.3-0.5 = small; 0.5-0.7 = small/medium; 0.7-1.1 = medium; 1.1-1.3 = medium/large; 1.3-1.9 = large; 1.9-2.1 = large/very large, and > 2.1 = very large[18]. The G*Power 3.1 software was used for effect size calculation.

RESULTS

A time x group interaction was observed for the two types of jumps (CMJ: F=26.23, p<0.01; SJ: F=23.16, p<0.01). The two groups did not differ in either type of vertical jump before the intervention (CMJ: p=0.09; SJ: p=0.32), indicating homogeneity of the sample. G11+ exhibited significant improvement in both jumps after the intervention, while no difference was observed for CG (Table 2). Thus, differences were observed between groups for the two types of jumps after training (p<0.01).

Table 2. Mean and standard deviation of jump height, percent change, ANOVA, and effect size.

Vertical jumps							
		Pre	Post	Absolute (cm)	% Change	ES	F(p)
G11+ (n=9)	CMJ (cm)	45.84 (±3.91)	51.04*# (±2.88)	5.2	11.39	1.47**	26.23 (<0.01)
GC (n=8)	CMJ (cm)	43.56 (±4.41)	44.66# (±3.91)	1.1	2.53	0.2	
G11+ (n=9)	SJ (cm)	41.33 (±2.7)	46.67*# (±2.71)	5.34	12.92	1.97**	23.16 (<0.01)
GC (n=8)	SJ (cm)	40.15 (±3.61)	40.66# (±3.57)	0.51	1.27	0.14	

CMJ = countermovement jump height; SJ = squat jump height; Absolute = absolute increase in the variable (post mean – pre mean); % Change = relative increase in the variable; ES = effect size; F = ANOVA. * Significant difference between pre- and post-intervention (p<0.05); # time x group interaction (p<0.01); ** ES classified as large (1.3-1.9).

DISCUSSION

The main finding of this study was that 9 weeks of intervention with the "FIFA 11+" program performed three times per week significantly improved the vertical jump variables in the intervention group (G11+ versus CG: CMJ = 11.39% versus 2.53% and SJ = 12.92% versus 1.27%) compared to CG, which maintained the normal training routine.

The proposal of incorporating the "FIFA 11+" warm-up program in the training routine has yielded good results in terms of both injury prevention[1,4,8,9] and improvement of performance indicators[2,3], although some authors suggested the stimuli not to be sufficient to induce significant effects[8,9]. The results confirm the initial hypothesis that G11+ would exhibit better vertical jump performance than CG. These findings suggest that the inclusion of "FIFA 11+" in the training routine could improve the ability of force production and especially enhance neuromuscular control[7]. According to Bizzini et al.[7], neuromuscular control is the interaction of systems that integrate different aspects of muscle actions (static, dynamic, and reactive), muscle activation (eccentric and concentric), inter- and intramuscular coordination, core stabilization, balance, and body posture.

The percentage change observed in the present study was higher than that reported by Daneshjoo et al.[2], who found an increase of 3.7% in jump height for professional soccer players. However, these authors did not use a force platform for the evaluation of jump height and the technique permitted the use of upper limp movement, facts that impair the comparison with our results. Bizzini et al.[10] evaluated the acute effect of "FIFA 11+" in 20 amateur soccer players by comparing the results with those of other warm-up routines (meta-analysis) and found improvement in vertical jump performance (CMJ: 5.5% and SJ: 6.2%), sprint ability and agility. According to the authors, "FIFA 11+" can be considered an adequate warm-up program for soccer players because it is able to induce positive acute and chronic physiological responses and is potentially effective in reducing injury risk factors. Additionally, the "FIFA 11+" is equally effective compared with other warm-up routines.

Reis et al.[19] tested the vertical jump performance (CMJ and SJ), isokinetic strength, 5-m and 30-m sprint ability, agility and balance of 36 futsal players after 12 weeks of intervention (twice a week) with the "FIFA 11+" program. The authors identified significant improvement in all tests for the intervention group, with an increase of 9.9% in CMJ and of 13.8% in SJ. The present findings agree with that study and the sprint and jump performance enhancement can be explained by the increase in the force production capacity observed in the study of Reis et al.[19], which was identified by the isokinetic tests that demonstrated an increase in concentric torque of the extensors and flexors and in eccentric torque of the knee flexors, as well as improvement in neuromuscular control promoted by the jumping exercises.

In the present study, vertical jump height was significantly improved ($p<0.01$) in G11+ (CMJ: 11.39%; SJ: 12.92%; effect size = 1.47 and 1.97, respectively), suggesting a very large effect of training on these variables. A possible explanation for the superiority of G11+ in terms of CMJ height is related to the enhanced training of eccentric hamstring contractions and plyometric exercises and their load progressions[10], which may have increased force production and SSC. In the latter case, the elastic structures of the muscles that contract eccentrically during the descending phase of CMJ accumulate elastic energy, which can be used during the ascending phase (concentric)[16]. According to Ugrinowitsch et al.[20], the amplitude of the countermovement used by the athlete is determinant for the efficiency of SSC and consequently influences CMJ height. The importance of the development of jumping ability is evident since explosive actions, such as vertical jumps, precede crucial actions in a soccer game[12]. Faude et al.[12], who evaluated the actions preceding a goal over half a season, observed that 58% of the goals converted by defenders occurred after a jump. In this respect, jumps, sprint ability and change in direction are extremely important in defensive situations when the athletes should react to an action of the opponent[12]. Thus, improved jumping ability can contribute to the performance of athletes in team sports.

The superiority of G11+ in terms of SJ height can be explained by improved neuromuscular control, core stabilization and increased force

production promoted by the specific exercises of the warm-up program (frontal and lateral bench, squats, and jumps)[10] and their load progressions, since only a concentric action of the muscle exists in SJ because of the lack of countermovement. Furthermore, jump height is basically related to the force production capacity of the athlete[21] due to the absence of contribution of the mechanisms of the eccentric phase described above. In SJ, since they start from a static position, the athletes need to apply greater force to accelerate the body in order to perform the movement[21]. In this respect, improvement of these scores indicates an increase in force production capacity, as demonstrated in studies that correlated maximum isometric and dynamic force with SJ performance[22,23] and observed that athletes with greater force levels exhibited better SJ performance. According to Faude et al.[12], after high-intensity actions, particularly straight sprints and vertical jumps that occur during crucial moments of a soccer game, it is essential that athletes train and develop these skills.

The "FIFA 11+" program was found to be effective in promoting a considerable increase in vertical jump performance. These results are interesting for coaches and athletes since this warm-up program can be developed without excessive time and financial expenditure. One limitation of this study is the fact that other neuromuscular parameters such as peak torque and the rate of force development were not measured.

CONCLUSION

It can be concluded that 9 weeks of intervention with the "FIFA 11+" program promoted a significant increase in the neuromuscular parameters (strength and power) of junior soccer players, as demonstrated by enhancement in vertical jump performance (CMJ and SJ) in the intervention group. However, the present results only reflect the effect of "FIFA 11+" on the junior category, and further studies involving infantile, juvenile and adult categories, as well as female athletes, are recommended.

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