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ORIGINAL RESEARCH

Isokinetic performance of U-13 futsal athletes after application of the FIFA 11+ protocol

Desempenho isocinético de atletas de futsal sub-13 após a prática do protocolo Fifa 11+

El rendimiento isocinético de atletas de fútbol sala sub-13 después de la práctica de protocolo Fifa 11+

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ABSTRACT | This study's objective was to evaluate U-13 futsal players' knee flexor and extensor muscles isokinetic performance, after a 18-week application of the FIFA 11+ protocol. Participants were male futsal players (n = 14) with a mean age of 12.58 ± 0.66 years. The force evaluation was performed pre- and post-intervention using the *Biodex System Pro 4*™ isokinetic dynamometer, at speeds of 60°/s, 180°/s, and 300°/s. The FIFA 11+ protocol was applied before the start of each regular training, twice a week, for 18 weeks, with an approximate duration of 25 minutes. In the pre-intervention analysis, a higher than 10% difference between dominant and non-dominant limbs was found in flexors' and extensors' peak torque, at the 60°/s and 180°/s speeds, respectively. In the post-intervention analysis, no such asymmetries were found. Post-intervention, there was an increase in the agonist-antagonist ratio on the dominant side, at the 60°/s speed, approaching the ideal value proposed in the literature (60%). There was also an increase in athletes' isokinetic performance. The 18-week application of the FIFA 11+ protocol promoted an improvement in the isokinetic performance of the knee's extensor and flexor muscles, and decreased the muscular asymmetries between the limbs of young futsal athletes.

Keywords | Muscle strength; Knee; Soccer; Athletes.

RESUMO | O objetivo deste estudo foi avaliar o desempenho isocinético da musculatura flexora e extensora do joelho de jogadores de futsal sub-13 após a prática de 18 semanas do protocolo Fifa 11+. Participaram 14 jogadores de futsal do sexo masculino com idade média de 12,58±0,66 anos. A avaliação da força foi realizada através do dinamômetro isocinético (*Biodex System Pro 4*™), nas velocidades de 60°/s, 180°/s e 300°/s, pré e pós-intervenção. O protocolo Fifa 11+ foi aplicado antes do início de cada treino regular, duas vezes por semana, durante 18 semanas, com duração aproximada de 25 minutos. Na análise pré-intervenção foi encontrada uma diferença entre o membro dominante e o não dominante superior a 10% no pico de torque de flexores e extensores a 60°/s e 180°/s, respectivamente. Já na análise pós-intervenção não foram encontradas tais assimetrias. Houve um aumento da relação agonista/antagonista no lado dominante na velocidade de 60°/s, pós-intervenção, aproximando-se do valor ideal proposto pela literatura (de 60%). Houve, ainda, aumento do desempenho isocinético dos atletas após a intervenção. Neste sentido, conclui-se que a aplicação de 18 semanas do protocolo Fifa 11+ promoveu uma melhora do desempenho isocinético das musculaturas extensoras e flexoras de joelho, além de diminuir as assimetrias musculares entre os membros em jovens atletas de futsal.

Descritores | Força Muscular; Joelho; Futebol; Atletas.

RESUMEN | El objetivo de este estudio fue evaluar el desempeño isocinético de la musculatura flexora y extensora de la rodilla de jugadores de fútbol sub-13 después de la práctica de 18 semanas del protocolo FIFA 11+. Participaron 14 jugadores de fútbol del sexo masculino con edad media

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de 12,58±0,66 años. La evaluación de la fuerza se realizó a través del dinamómetro isocinético (Biodex System Pro 4 ™), a velocidades de 60°/s, 180°/s y 300°/s, pre y post-intervención. El protocolo FIFA 11+ fue aplicado antes del inicio de cada entrenamiento regular, dos veces por semana, durante 18 semanas, con una duración aproximada de 25 minutos. En el análisis previo a la intervención se encontró una diferencia entre el miembro dominante y el no dominante superior al 10% en el pico de torque de flexores y extensores a 60°/s y 180°/s, respectivamente. En el análisis post-intervención no se encontraron tales asimetrías. Se observó un aumento de la relación agonista / antagonista en el lado dominante en la velocidad de 60°/s, post-intervención, aproximándose al valor ideal propuesto por la literatura (del 60%). Se observó un aumento del rendimiento isocinético de los atletas después de la intervención. En este sentido, se concluye que la aplicación de 18 semanas del protocolo FIFA 11+ promovió una mejora del desempeño isocinético de las musculaturas extensoras y flexoras de rodilla, además de disminuir las asimetrías musculares entre los miembros en jóvenes atletas de fútbol.

Palabras clave | Fuerza Muscular; Rodilla; Fútbol; Atletas.

INTRODUCTION

Futsal involves considerable physical contact and gestures unique to the modality, leading to high rates of musculoskeletal injuries. Lesions in this sport modality occur predominantly in the lower extremity of the body, with knees and ankles being the most affected parts[1,2].

Risk factors associated with the development of sports injuries may be directly related to muscle performance parameters, such as muscle torque, work, power and endurance. Among instruments to evaluate such data is the isokinetic dynamometer, widely used in scientific research due to providing accurate and easily validated data[3].

Considering the aforementioned parameters, fixed values of the muscle strength ratio between the knee's agonist and antagonist muscles other than 60%[4] and differences greater than 10% in bilateral relationships may be determining factors for knee joint injuries[5]. Therefore, in futsal, the evaluation of knee muscles' functional performance is essential, both as guidance for rehabilitation programs and injury prevention[4].

Young people's futsal initiation has been occurring earlier, especially for boys, and thus greater attention is being dispensed to injury prevention programs at earlier ages. These athletes are still in a stage of development and maturation of their musculoskeletal and neural systems[6,7]. In fact, there are studies evidencing that the implementation of neuromuscular and physical conditioning training decreases the frequency and severity of injuries in athletes aged 13 to 19 years[6,8].

To this end, the FIFA 11+ injury prevention protocol[9] was created. It consists of a warm-up program which includes central stabilization exercises, balance, dynamic stabilization and eccentric strengthening of the hamstrings[9], proving effective in reducing lower limb injuries in soccer players[10,11].

Results of this protocol were observed in soccer athletes aged over 13 years, as attested by a systematic review[12] in which the FIFA 11+ protocol reduced the risk of injury by 30%. Positive results were also observed in another review[13], showing a decrease in the incidence rate of lesions in girls aged 13 to 17 years. However, studies reporting the effects of this program on male athletes under 13 are still limited. In addition to the age factor, it is worth noting that despite the similarities between futsal and soccer, there is still a lack of research concerning the use of FIFA 11+ in young futsal athletes[14].

This study aims to evaluate the isokinetic performance of knee flexor and extensor musculature in U-13 futsal players, following the application of the 18-week FIFA 11+ program.

METHODOLOGY

Sample

This study was approved by the Research Ethics Committee of the Federal University of Pampa, under protocol no. 1,685,733. The athletes' legal guardians signed an Informed Consent Form, and the participants themselves signed a consent form. The inclusion criteria were: male players aged 11 to 13 years old, members of the Sports Association of Uruguaiana–in Uruguiana, RS, Brazil–who had been in regular training for at least three months prior, with no history of lesions in inferior limbs during the last six months. Exclusion criteria were: athletes suspended from the team for any health reason or due to being in rehabilitation; athletes who

did not present a minimum assiduity of 75% during the study's timespan.

The initial sample consisted of 17 U-13 futsal players who were playing for the 2017 state championship of Rio Grande do Sul. It should be noted that all the members of the team underwent a previous general medical evaluation and that none of them used any medications during the intervention period. Athlete training was conducted three times a week, lasting two hours, including a warm-up phase, technical and tactical training in the sport's main abilities (conducting the ball, passing, receiving, dribbling, shooting, head balls, tight marking, control), and training matches.

Sample characterization evaluated age, training time, lower limbs dominance (as reported by athletes, considering the side used to perform kicks as the dominant side), and anthropometric data (mass and stature). After these evaluations, three athletes were excluded because they failed to reach a 75% assiduity in the training program; thus, 14 players remained. Anthropometric data are presented in Table 1.

Table 1. Sample characterization

Variable	Mean and ± SD
N	14
Age (years)	12.58±0.66
Mass (kg)	44.92±7.08
Height (m)	1.55±0.08

Descriptive data, mean and standard deviation (±SD).

Isokinetic evaluation

The protocol used in this study was based on the work of Ferreira et al.[15], who evaluated the isokinetic performance of knee muscles in a sample of futsal players.

Athletes performed a 5-minute warm-up on an exercise bike with no load, aimed at maintaining a constant heart rate of 60 bpm. The rest time between the warm-up and the beginning of muscle strength tests was 90 seconds.

Participants performed five maximal repetitions of knee flexion and extension at a velocity of 60°/s; ten repetitions at 180°/s; and 15 repetitions at 300°/s, bilaterally, with a 60-second interval between sets, using the concentric mode. The choice of the first limb to be tested was randomized, and there was a 60-second interval between testing the dominant (DL) and the non-dominant (NDL) limb. The procedures adopted during the examination were in accordance with the criteria set by Ferreira et al.[15]

Muscle strength was assessed before and after the intervention, using the Biodex *System Pro 4*™ isokinetic dynamometer (*Biodex Medical Systems, Inc.*, New York, USA). Isokinetic evaluation is a reliable tool to assess muscle strength. The most used parameters in athletes' functional performance characterization are peak torque (PT), power (POW), total work (TW), fatigue index (FI) and agonist-antagonist relationship (AAR)[16,17]. Asymmetries greater than 10% in limbs' peak torque represent a high risk of injuries[5]. Normal AAR values are 60% at low speeds (60-180°/s) and 80% at high speeds (300°/s)[5]. For knee flexors and knee extensors, the FI variable should be below 50%[18].

Intervention protocol

The FIFA 11+ protocol was applied before the beginning of each regular training, twice per week[19] during 18 weeks, with each session lasting approximately 25 minutes. It should be noted that the protocol was carried out only before regular training sessions, not before championship games. Soligard et al. employed a similar intervention period[10], in a study in which the athletes were monitored while participating in a championship. The authors found that the risk of serious injuries (0.68 ratio, 95% confidence interval, 0.48 to 0.98), overuse injuries (0.47, 0.26 to 0.85), and overall injuries (0.55, 0.36 to 0.83) was reduced in the group of athletes who had participated in the preventive program.

The program was comprised of three stages, according to Soligard et al.[10] Part one consisted of reduced-speed running exercises, combined with contacts with the partner; part two had three levels of difficulty and involved plank, lateral plank, squat, jumping and balance exercises; part three had moderate to high-speed racing exercises, combined with specific soccer moves. Every four weeks, the exercises performed in step two progressed a level, as proposed by Soligard et al.[10]

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20.0 was used for descriptive analysis, with means and standard deviations. The data normality test (via Shapiro–Wilk) indicated a parametric distribution. Differences between tests (pre- and post-protocol) were evaluated using the paired Student's t-test. A significance level of less than 0.05 was considered for all analyzes.

RESULTS

Table 2 demonstrates the knee isokinetic performance of the 14 athletes at the 60°/s speed. After the intervention, there was an increase in most variables, with the exception of DL extensors' PT and NDL's AAR. Before the intervention, a greater than 10% asymmetry between athletes' limbs in regard to flexors' PT was found.

Athletes' isokinetic variables at the 180°/s speed are shown in Table 3. After the intervention, there was a significant increase in most variables, with the exception of NDL extensors' PT and both limbs' AAR. Before the intervention, there was a greater than 10% asymmetry between athletes' limbs in regard to flexors' PT.

Regarding isokinetic performance at the 300°/s speed (Table 4), the intervention had no effect on DL flexors' PT, both limbs' AAR, or both limbs' FI for extensors and flexors. All the other variables increased after the intervention.

Table 2. Isokinetic performance of knee joint at 60°/s, before and after intervention

	PRE Dominant	POST Dominant	P	PRE Non-dominant	POST Non-dominant	P
Extensors PT	103.53±21.68	110.13±26.91	0.11	101.23±20.33	115.59±26.07	0.003*
Flexors PT	56.43±11.87	63.54±13.68	0.001*	50.39±11.90	60.72±16.88	0.003*
Extensors TW	466.60±96.01	527.68±98.36	0.003*	425.33±88.50	543.76±145.27	<0.001*
Flexors TW	267.10±57.29	316.80±78.98	0.007*	232.40±75.63	296.35±97.02	0,006*
Extensors POW	66.82±13.32	76.82±16.24	0.000*	64.86±13.55	80.06±19.49	<0.001*
Flexors POW	38.75±7.39	46.79±10.98	0.003*	34.94±10.47	43.87±13.15	0.003*
AAR	54.51±4.29	57.98±4.38	0.037*	49.96±8.40	52.30±6.62	0.338

PT: peak torque (Nm), TW: total work (J), POW: power (watts), AAR: agonist-antagonist relationship (%) between flexors and extensors. Data expressed as mean and standard deviation (±SD), * indicates significant difference (p<0.05).

Table 3. Knee joint isokinetic performance at the 180°/s speed, before and after intervention

	PRE Dominant	PRE Dominant	P	POST Non-dominant	POST Non-dominant	P
Extensors PT	77.98±17.20	86.26±17.22	0.001*	92.40±33.64	91.13±19.02	0.901
Flexors PT	50.66±11.24	57.96±13.22	0.002*	46.13±9.27	54.88±12.80	0,006*
Extensors TW	797.33±182.0	911.70±180.2	0.003*	830.36±192.26	964±199.37	0.003*
Flexors TW	515.95±119.8	592.99±126.78	<0.001*	473.76±155.64	551.58±135.07	0.028*
Extensors POW	130.06±29.42	148.88±28.62	0.002*	132.23±30.09	155.54±34.41	0.016*
Flexors POW	81.72±18.56	94.01±19.29	<0.001*	473.76±155.64	551.58±135.07	0.035*
AAR	65.27±7.09	67.00±7.16	0.406	55.79±6.79	60.17±6.73	0.106

PT: peak torque (Nm), TW: total work (J), POW: power (watts), AAR: agonist/antagonist relationship (%) between flexors and extensors. Data expressed as mean and standard deviation (±SD), * indicates significant difference (p<0.05).

Table 4. Knee joint isokinetic performance at the 300°/s speed, before and after intervention

	PRE Dominant	POST Dominant	P	PRE Non-dominant	POST Non-dominant	P
Extensors PT	64.15±11.98	68.54±14.08	0.017*	67.63±11.95	74.17±15.80	0.007*
Flexors PT	48.25±9.49	54.38±9.96	0.056	46.70±12.64	56.11±11.68	0.043*
Extensors TW	894.16±227.2	1050.15±15	0.003*	929.39±222.42	1131.43±251.40	0.003*
Flexors TW	584.72±174.2	716.14±154.14	0.005*	536.26±178.68	680.54±168.09	0.003*
Extensors POW	139.31±34.82	162.25±34.60	0.002*	141.80±32.73	173.23±39.90	0.002*
Flexors POW	85.51±24.92	103.95±22.91	0.002*	74.90±24.32	98.29±24.14	0.001*
AAR	75.95±14.09	80.19±10.94	0.394	69.78±17.39	76.44±10.85	0.200
FI ext	28.85±9.94	34.45±6.51	0.150	26.95±11.82	32.50±6.91	0.119
FI flex	32.01±10.88	37.47±9.21	0.258	35.06±10.99	31.23±8.39	0.412

PT: peak torque (Nm), TW: total work (J), POW: power (watts), AAR: agonist/antagonist ratio (%) between flexors and extensors, FI ext: extensor fatigue index, FI flex: flexor fatigue index (%). Data expressed as mean and standard deviation (±SD), * indicates significant difference (p<0.05).

DISCUSSION

The study demonstrates important contributions of the FIFA 11+ injury prevention protocol on isokinetic knee joint variables in futsal athletes: the intervention led to reductions in bilateral (at the 60°/s and 180°/s speeds) as well as unilateral asymmetries (at the 60°/s speed). It should be noted that the aforementioned data are scarce in the literature, since the overwhelming majority of research findings are restricted to young adults.

Preventive work involving younger ages is fundamental, as suggested by some studies[20,21]. Read et al.[20], when analyzing possible asymmetries in 347 juvenile soccer athletes according to maturation stage, found that functional performance differences among young athletes appear in early childhood. The authors suggest that preventive interventions should begin sooner, at ages prior to peak growth velocity, and be maintained during childhood and adolescence to ensure asymmetry does not increase. In the same vein, Atkins et al.[21] identified that bilateral muscular imbalances become relevant in early adolescence. At the end of this stage, the differences are diminished. The authors reiterate the possibility of a "trigger" during the early stage of adolescence, when bilateral imbalances become marked. However, the reasons for this type of asymmetry to become pronounced precisely during this stage remain uncertain. In any case, specific training aimed at reducing muscular imbalances of lower limbs in young players contributes to reducing the risk of injuries[21].

In agreement with our results, some studies have also demonstrated that the FIFA 11+ protocol has beneficial effects on athletes' muscular performance. Brito et al.[22], after a 10-week application of the protocol in 20 male soccer players (22.3 ± 4.2 years), found a significant increase in NDL extensors' PT, in both limbs' flexors, and in NDL AAR at the 60°/s speed. At the 180°/s speed, there was an increase in DL extensors' and NDL flexors' PT, corroborating this study's findings.

Reis et al.[23] found that a 12-week FIFA 11+ application in 36 futsal players (17.3 ± 0.7 years) was effective in increasing NDL knee extensors' and DL knee flexors' PT (at 60°/s), in addition to improving DL AAR. At the highest speed, however, the authors reported no change in any of the evaluated variables, whereas in our study there was an increase in DL extensors' PT, as well as flexors' PT, for both limbs.

Studies by Daneshjoo et al. (36 male soccer players, 18.9 ± 1.4 years) and Ghareeb et al.[25] (17 male soccer players, 16.53 years) also found that the protocol increased knee flexors' PT at the three tested velocities (60°/s, 180°/s and 300°/s), as well as knee extensors' PT at 300°/s[24]. Moreover, as in our study, Daneshjoo et al.[26] found that the protocol provided significant AAR improvements in male soccer players (ages 17 to 20).

It should be noted that the results found in this study-pointing to a better unilateral muscular balance and to an increase in knee flexor muscles' PT-may be associated to the characteristics of the applied protocol, which included Nordic exercises targeting this specific musculature. These gains are important in the preventive context, as suggested by van der Horst et al.[27] in a study with male soccer amateur athletes, in which the incidence of lesions in the posterior thigh muscles was shown to be significantly lower in the group that practiced Nordic exercises, as compared to the control group.

In this study, a team of futsal athletes was monitored during a 18-week period of preventive program application. Similarly, Soligard et al.[10] followed female soccer athletes (15.4±0.7 years) during a league championship, and identified a reduction in the risk of serious injuries, overuse injuries and overall injuries. However, the period of FIFA 11+ application in the assessed studies was highly variable. This factor does not seem to be clearly defined in the literature and should be better investigated.

The FI variable was within expected values[18]. Values for this variable are important, considering that in a futsal game the most used muscle groups are the quadriceps and the hamstrings. In a situation of muscular fatigue, strength and muscle power are reduced, possibly compromising the athlete's match performance and increasing the risk of injuries[28].

The evaluation of isokinetic performance as conducted in this study aids in identifying muscle deficits associated with injury risks, and in monitoring the effects of training programs, thus helping to prevent injuries[16,29]. The muscular symmetry between limbs and the relationship between the knees' flexors and extensors are crucial factors in futsal athletes' care, due to the function of these muscles in the sport's specific practices[30].

In this study, a pre-intervention asymmetry greater than 10% was found in flexors' PT at 60°/s and in extensors' PT at 180°/s, characterizing a risk factor for injuries[5]. In the post-intervention analysis no such asymmetries were found, suggesting that the protocol influenced the reduction of strength asymmetries between limbs. Regarding the AAR data, there was a post-intervention increase in this variable in respect to DLs (at 60°/s), approaching the ideal value[18]. Although this variable did not change at the other analyzed velocities, or in NDLs at 60°/s, the values grew closer to normality[18] after the intervention.

The reduction in unilateral and bilateral muscular asymmetries found in this study may also contribute to reduce the risk of athletes developing lesions. Corroborating this, a systematic review with meta-analysis by Al Attar et al.[31] reported that teams involved in the FIFA 11+ warming program reduced injury rates by 20% to 50% in the long term, as compared to teams who had not participated in preventive programs.

As limitations of this study, we can mention the athletes' lack of familiarity with the isokinetic test, the lack of a maturational evaluation, the lack of a sample calculation, and the lack of a control group allowing for more conclusive results.

CONCLUSION

The application of the FIFA 11+ protocol for a period of 18 weeks promoted an improvement in the isokinetic performance of knee extensor and flexor muscles, reducing unilateral and bilateral asymmetries in young futsal athletes and, therefore, reducing the risk of developing lesions.

This study contribution is to demonstrate positive effects of an injury prevention program on the muscular performance of U-13 male futsal athletes, considering that preventive work aimed at this category remains limited. Further studies involving the effects of the Fifa11+ program on different futsal base categories are suggested.

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