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ORIGINAL RESEARCH

Analysis of the postural balance and knee isokinetic muscle strength of female futsal players

Análise do equilíbrio postural e força muscular isocinética de joelho em atletas de futsal feminino

Análisis del equilibrio postural y fuerza muscular isocinética de rodilla en deportistas de fútbol sala femenino

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ABSTRACT | Indoor football (futsal) is the sport with the largest number of practitioners nowadays, which implies a greater appearance of lesions. Thus, it is important to identify variables that may predispose the athlete to develop injuries, such as balance and muscle strength. This study aimed to assess the postural balance and knee isokinetic muscle strength in amateur female futsal players – 12 athletes were evaluated (22.07±3.61 years) – and to investigate the association between these variables. The knee muscle strength was evaluated using an isokinetic dynamometer and balance with computerized dynamic posturography, through sensory organization test (SOT), motor control, and unilateral test. The athletes showed greater visual dependency to maintain balance, which was perceived in the conditions of the unilateral test with visual restriction. Possibly, this situation indicates that the somatosensory and/or vestibular system of the athletes was affected by factors associated with the physical training and participation in competitions. Concerning the isokinetic muscle strength variables, there was no indication of muscle imbalance, through agonist-antagonist ratio, in the dominant lower limb (53.8±8.4%), nor in the non-dominant lower limb (55.1±10.9%). There was association between balance and variables of isokinetic strength, indicating that the greater the muscle power, the better the proprioceptive level (SOT 4 condition), and the higher the total work, the better the state of the proprioceptive and vestibular systems (SOT 5 condition).

Keywords | Athletic Injuries; Muscle Strength; Postural Balance.

RESUMO | O futebol de salão (futsal) representa, atualmente, o esporte com maior número de praticantes, fator que implica grande surgimento de lesões. Assim, é relevante identificar variáveis que podem predispor o atleta ao desenvolvimento de lesões, como o equilíbrio e a força muscular. O objetivo deste estudo é analisar o equilíbrio postural e a força muscular isocinética do joelho em atletas amadoras de futsal feminino – foram avaliadas 12 atletas (22,07±3,61 anos) –, e verificar se existe associação entre essas variáveis. Mediu-se a força muscular com um dinamômetro isocinético, e o equilíbrio, por meio da posturografia dinâmica computadorizada, com testes de organização sensorial (TOS), de controle motor e unilateral. As atletas mostraram maior dependência visual para manter o equilíbrio, percebida nas condições do teste unilateral com restrição visual. Possivelmente, essa situação indica que o sistema somatossensorial e/ou vestibular das atletas foi afetado por fatores associados ao treinamento físico e à participação em competições. Quanto às variáveis de força muscular isocinética, não houve indicação de desequilíbrio muscular pela relação agonista-antagonista no membro inferior dominante (53,8±8,4%), nem no não dominante (55,1±10,9%). Houve associação entre equilíbrio e variáveis de força isocinética, indicando que quanto maior a potência muscular, melhor o nível proprioceptivo (condição 4 do TOS) e, quanto maior o trabalho total, melhor o estado dos sistemas proprioceptivo e vestibular (condição 5 do TOS).

Descritores | Lesões Esportivas; Força Muscular; Equilíbrio Postural.

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RESUMEN | El fútbol sala representa actualmente el deporte con el mayor número de practicantes, lo que implica mayor aparición de lesiones. Así, es relevante identificar variables que pueden predisponer el deportista al desarrollo de lesiones, como el equilibrio y la fuerza muscular. El objetivo de este estudio es analizar el equilibrio postural y la fuerza muscular isocinética de la rodilla en deportistas aficionadas de fútbol sala femenino – se evaluaron 12 deportistas (22.07±3.61 años) – y verificar se existe asociación entre esas variables. La fuerza muscular fue medida con un dinamómetro isocinético y el equilibrio por medio de la posturografía dinámica computarizada, con pruebas de organización sensorial (SOT), de control motor y unilateral. Las deportistas mostraron mayor dependencia visual para mantener el equilibrio, lo que se percibió en las condiciones de la prueba unilateral con restricción visual. Posiblemente, esa situación indica que el sistema somatosensorial y/o vestibular de las deportistas fue afectado por factores asociados al entrenamiento físico y a la participación en competiciones. En cuanto a las variables de fuerza muscular isocinética, no hubo indicios de desequilibrio muscular, por medio de la relación agonista-antagonista, en el miembro inferior dominante (53,8±8,4%), ni en el no dominante (55,1±10,9%). Hubo asociación entre equilibrio y variables de fuerza isocinética, lo que indica que, cuanto mayor la potencia muscular, mejor el nivel propioceptivo (condición 4 de las SOT), y cuanto mayor el trabajo total, mejor el estado de los sistemas propioceptivo y vestibular (condición 5 afección de las SOT).
Palabras clave | Lesiones Deportivas; Fuerza Muscular; Equilibrio Postural.

INTRODUCTION

Indoor football (futsal) is currently the most played sport both in Brazil as in other South American countries and also in Europe[1]. From this perspective, the female category is gaining more space in Brazil because of investments in the dissemination of this activity[2].

Angoorani et al.[3] report that sport injuries are common in futsal, and female athletes are more prone to develop such lesions when compared to the male category. In fact, this sport has specific characteristics, since it is associated with greater speed in smaller fields, increaseing the risk of collisions[4]. Considering that injuries cause the withdrawal of the athlete[5] from competitions, it is important to identify the variables that may predispose to the development of lesions to create prevention strategies in this sport.

Muscular strength is an important variable to identify individuals who may develop musculoskeletal injuries. The isokinetic evaluation allows to identify and quantify the performance and muscle balance of athletes[7].

As muscular strength, a better balance is also relevant for preventing injuries in sports, since deficit in the proprioceptive system is associated with lesions in futsal[8]. In fact, there is evidence of the effectiveness of the neuromuscular and proprioceptive training on the reduction of sport injuries[9].

This study aimed to analyze the postural balance and knee isokinetic muscle strength in amateur female futsal athletes, and to investigate the association between them. We expect to find associations between a better proprioceptive level and better isokinetic performance in these athletes.

METHODOLOGY

In this cross-sectional study, the sample consisted of amateur female futsal players from the city of Uruguaiana, Rio Grande do Sul (RS), Brazil, who were in regular training and in a team for at least 6 months. Exclusion criteria of the study were athletes in rehabilitation for any injury or in absence for health reasons. The study was approved by the Ethics and Research Committee of Universidade Federal do Pampa, under approval no. 1,283,221, and the participants signed an informed consent form (ICF).

After analyzing these criteria, 14 athletes were able to participate in the study; however, two participants did not attend the evaluation previously marked, remaining 12 athletes. These athletes participated in the assessment protocol, including:

- Questionnaire about personal data and prior injuries;
- Anthropometric assessment (Table 1), including body weight and height;
- Muscular strength evaluated by an isokinetic dynamometer (Biodex-System PRO 4) – these data allowed to assess the strength and muscular balance[10]. The athletes performed a maximum of 5 repetitions of knee flexion and extension in

concentric/concentric mode at 60°/s, receiving auditory and visual stimulation to develop maximum strength in each repetition. The athletes were positioned in the sitting posture and stabilized with diagonal thoracic strips and transverse abdominal strips, and with a bandage in the distal region of the thigh to be tested. The test-retest reliability at 60°/s has already been demonstrated[11].

- Postural balance: Evaluated through computerized dynamic posturography (CDP), EquiTest System® (NeuroCom International, Inc.). CDP evaluates the neural systems responsible for the balance through vestibular, proprioceptive, and visual afferent stimuli[12]. The following tests were carried out:

Table 1. General characteristics of the injuries*

Characteristics	N (%)
Number of athletes who have suffered injury	11 (91.66%)
Situation of the injury	
Technical/tactical training	2 (16.66%)
Match	8 (66.66%)
Physical training	1 (8.33%)
Condition	
With contact	5 (41.66%)
Without contact	6 (50%)
Period of absence and severity of injury	
Mild (up to six days)	11 (91.66%)
Moderate (seven to 28 days)	
Severe (> 28 days)	
Affected body part	
Head, face, neck	
Upper limb	1 (8.33%)
Trunk	
Thigh	7 (58.33%)
Knee	2 (16.66%)
Leg	
Ankle	1 (8.33%)

*Analyses of N frequencies and percentage (%)

a) Sensory Organization Test (SOT): divided into 6 conditions – conditions 1, 3 and 6 assess the proprioceptive, vestibular and visual system; conditions 2 and 5 assess the proprioceptive and vestibular system and condition 4 evaluates the proprioceptive system. Casselbrant et al.[13] propose values of normality under SOT conditions for healthy adults;

b) Motor control test: through the tests of weight symmetry and strength symmetry[14];

c) Unilateral test: it evaluates the instability degree of each lower limb (with and without visual restriction), and higher values indicate greater instability[14].

For the statistical analysis, we used GraphPad Prism 5 (GraphPad Software Inc., San Diego, CA, USA), with descriptive analysis through mean and standard deviation and frequencies. After testing the normality of the data via Kolmogorov-Smirnov test, a parametric distribution was indicated. Thus, we used the paired t-test for comparing the variables related to the unipodal balance, and Pearson's correlation was performed to identify the association between the variables of muscular strength and postural balance. A significance level of 0.05 was considered for all analyses.

RESULTS

Twelve athletes were assessed, 22.07±3.61 years old (59,42±7,24 kg and 1,61±0,05 m). Regarding the general characteristics of lesions (Table 1), we observed that 11 (91.66%) athletes suffered injuries in the last 24 months, of which 66.66% occurred during the match. The circumstances of the injuries were recorded according to the occurrence or not of contact (direct or indirect trauma), with predominance of non-contact injuries. Most of them resulted in mild trauma, being the thigh the most affected body part.

Regarding the postural balance profile (Table 2), the athletes presented the six SOT conditions, composite value and motor control tests within the range considered normal for healthy adults. In the unilateral test, differences were found in the comparison between open and closed eyes in the dominant lower limb (DLL) and non-dominant lower limb (NDLL).

The variables of peak torque, total work, power, and agonist/antagonist relationship are presented in Table 3. There was no difference in the comparison of these variables between the DLL and the NDLL.

By associating the isokinetic muscle strength and postural balance, it was possible to identify a positive correlation between the flexion power of the NDLL and the condition 4 of the SOT (Graph 1), and between the total work of knee extensors in the DLL and the condition 5 of SOT (Graph 2).

Table 2. Profile of the postural balance of female futsal players*

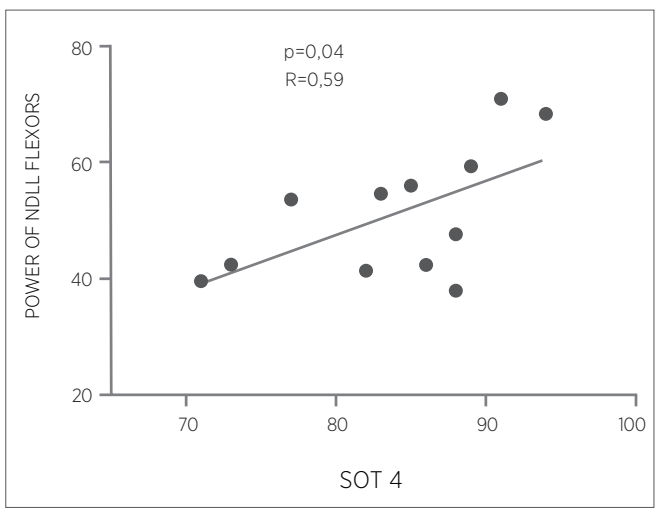
Variable	Mean and SD±	Reference values
Sensory Organization Test		
SOT 1 (%)	94.59±1.50	93
SOT 2 (%)	93.00±1.47	92
SOT 3 (%)	91.08±2.4	88
SOT 4 (%)	83.91±7.10	83
SOT 5 (%)	68.91±8.7	64
SOT 6 (%)	65.50±13.8	59
Composite (%)	79.75±5.59	76
Motor control test		
Weight symmetry (°/s)	99.94±1.26	90-110
Strength symmetry (°/s)	100.73±9.68	100
Unilateral test		
Open NDLL (ms)	0.54±0.11[a]	
Closed NDLL (ms)	1.7±0,56[b]	
Open DLL (ms)	0.67±2.1[a]	
Closed DLL (ms)	1.72±0, 69[b]	

DLL: dominant lower limb; NDLL: non-dominant lower limb; SOT: Sensory Organization Test.
*Different letters indicate significant difference (p<0.05).

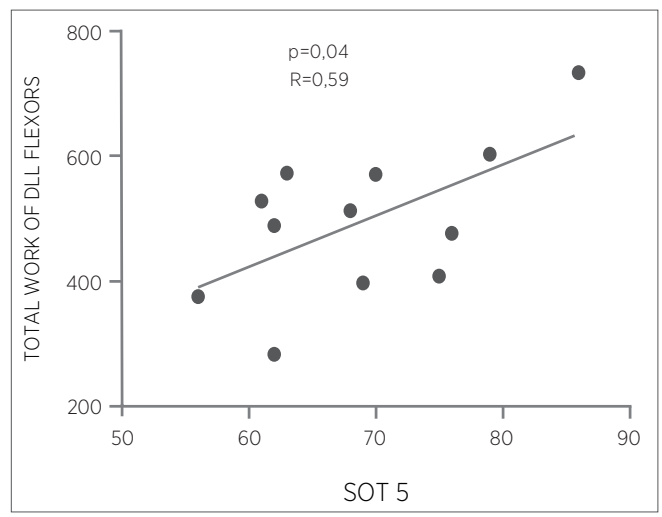
Table 3. Isokinetic evaluation of the knee of female futsal players*

Variable	DLL - EXTENSION	DLL - FLEXION	NDLL - EXTENSION	DLL - FLEXION
Peak torque (Nm)	140±25.34	75.7±17.8	145.7±20.6	80.6±22
Total work (J)	498.6±120.9	309±104.1	540.4±131.6	339.8±97.2
Potency (W)	78.8±19.5	47.4±16.8	86.1±15.8	51±11.1
Agonist/antagonist relationship (%)	53.8±8.4	-	55.1±10.9	-

DLL: dominant lower limb; NDLL: non-dominant lower limb.
*Data expressed as mean and standard deviation SD±.



Graph 1. Correlation between Sensory Organization Test (SOT 4) and power of knee flexors in the non-dominant lower limb.



Graph 2. Correlation between Sensory Organization Test (SOT 5) and total work of knee flexors in the dominant lower limb.

DISCUSSION

This study showed that in the last 24 months, 11 of the 12 athletes evaluated suffered injury, most of the time without contact and during the matches, resulting in mild trauma and having the thigh as the body part most affected.

Fernandes et al.[15] reiterate that football is one of the sports with the highest incidence of injuries. However, issues involving the affected body parties, severity of injuries and circumstance are still controversial.

In the study by Gayardo et al.[5], the incidence of injuries in female futsal players was high, and the thigh was the most affected part. There was predominance of non-contact injuries, being classified as moderate regarding the gravity. Another study that examined the epidemiology of injuries in futsal verified that 65.62% were classified as mild and occurred by direct contact[16].

Silva et al.[17] evaluated 17 female futsal players and verified that the ankle was the anatomical region most affected by injuries. However, high rates of thigh injuries were found in the study of Jacobson and Tegner[18], who evaluated elite female football teams.

Although the values of the SOT and the motor control tests are within the normal range, such values refer to healthy adults and not athletes, considering the data gap related to the CDP in this population. Corroborating this, Oda and Ganança[19] report a lack of studies on CDP, and that it should be more studied in different populations, since SOT is the only test available that provides quantitative data on the functionality of the three systems that influence balance[19].

Considering that proprioception is crucial to joint stability and associated with prevention of sport injuries[20], its assessment becomes relevant[21]. In football, better proprioceptive conditions are important due to the overload associated with changes of direction during the running, so frequent in this sport[22].

In this study, the unilateral test indicated higher values in the conditions related to eyes closed in comparison with eyes open. Bieć et al.[23] compared the balance between football players of the U-14 and U-20 categories. It was observed that U-20 players had better performance in the conditions in which their eyes were open, compared to the other group; however, this performance decreased with the eyes closed, similar to what was found by our study. The authors explain that the biggest visual dependency in the U-20 group resulted from a longer exposure of these players to strenuous exercise, overloads, as well as residual effects from previous injuries. They also showed that the dependence on the visual system of these players, in comparison to the younger group, indicates that their somatosensory and/or vestibular system was affected by factors associated with the physical training and participation in tournaments and competitions. This factor seems to explain the data found in our study, since the athletes are almost 20 years old, with history of previous injuries, and they train and participate in tournaments and competitions regularly.

In our study, there were no differences in the variables of isokinetic strength between DLL and NDLL. This factor is relevant once the maximum difference between the legs represents a risk factor for knee joint lesions[24]. According to the literature, the agonist/antagonist ratio must be around 60% at 60°/s, and values below 50% indicate severe degree of muscular imbalance[25], a fact that did not occur with our sample.

In our study, there was no association between postural balance and muscle strength, corroborating the data of other studies that show this relationship in athletes[26,27]. Mohammadi et al.[28] found that strength training increased the balance of athletes, and suggest that this factor is related to the process of reduction, disinhibition and stimulation of muscle spindles. Young and Metzl[29] relate the best balance with increased muscle strength, considering that strength training helps the recruitment of fast-twitch motor units, which increases neuromuscular coordination.

Although this study did not assess the muscle fatigue index of athletes, it is relevant to infer that this condition is characterized by a gradual reduction in the production capacity of muscle strength[30]. In this sense, Gomes et al.[31] describe that muscular fatigue may decrease the balance of the football players' support leg and, thus, their performance, since the positioning of the athlete's support leg influences the accuracy, speed and range of the ball[32]. This factor contributes to explain the results of our study, since the largest muscle power in DLL (support leg) was associated with a better proprioceptive condition (condition 4 of the SOT) of athletes.

Pau et al.[33] identified that players with muscle fatigue showed reduced performance in the postural control system, and, therefore, they concluded the increased risk of lower limb injuries in young athletes can be attributed to the muscle fatigue due to an altered neuromuscular control. Thus, these authors pointed out training programs

of the lower limb muscle strength and balance must be included in regular training sessions, since there is a direct relationship between these variables, according to our study.

CONCLUSION

Although SOT and motor control tests are within normal values, the athletes showed a greater visual dependence to maintain balance, perceived in the conditions of the unilateral test with visual constraint, regardless of the member evaluated. As for the variables of isokinetic muscle strength, there was no indication of muscle imbalance in the sample by the agonist-antagonist relation. We found an association between the postural balance and variables of isokinetic muscle strength.

As contributions, this study presents values for knee isokinetic muscle strength and values of posturography in a sample of amateur female futsal players, since our data are limited.

REFERENCES

1. Lefchak FJ, Longen WC. Existe relação entre o tipo de piso da quadra de futsal e respostas adaptativas da musculatura em praticantes de futsal masculino? Rev Bras Med Esporte. 2014;20(1):8-12. doi: 10.1590/S1517-86922014000100001
2. Confederação Brasileira de Futebol de Salão. Futsal: origem [Internet]. CFBS: Fortaleza; 2015. [citado em 2018 fev 6]. Disponível em: http://www.cbfs.com.br/2015/
3. Angoorani H, Haratian Z, Mazaherinezhad A, Younespour S. Injuries in iran futsal national teams: a comparative study of incidence and characteristics. Asian J Sports Med. 2014;5(3):e23070. doi: 10.5812/asjsm.23070.
4. Junge A, Dvorak J, Graf-Baumann T, Peterson L. Football injuries during FIFA tournaments and the Olympic Games, 1998-2001: development and implementation of an injury-reporting system. Am J Sports Med. 2004;32(1):80-9. doi: 10.1177/0363546503261245
5. Gayardo A, Matana SB, Silva MR. Prevalência de lesões em atletas do futsal feminino brasileiro: um estudo retrospectivo. Rev Bras Med Esporte. 2012;18(3):186-9. doi: 10.1590/S1517-86922012000300010
6. Silva Neto M, Simões R, Grangeiro Neto JA, Cardone CP. Avaliação isocinética da força muscular em atletas profissionais de futebol feminino. Rev Bras Med Esporte. 2010;16(1)33-5. doi: 10.1590/S1517-86922010000100006
7. Zabka FF, Valente HG, Pacheco AM. Avaliação isocinética dos músculos extensores e flexores de joelho em jogadores de futebol profissional. Rev Bras Med Esporte. 2011;17(3):189-92. doi: 10.1590/S1517-86922011000300008
8. Baldaço FO, Cado VP, de Sousa J, Mota CB, Lemos JC. Análise do treinamento proprioceptivo no equilíbrio de atletas de futsal feminino. Fisioter Mov. 2010;23(2):183-92. doi: 10.1590/S0103-51502010000200002
9. Emery CA, Roy TO, Whittaker JL, Nettel-Aguirre A, Mechelen WV. Neuromuscular training injury prevention strategies in youth sport: a systematic review and meta-analysis. Br J Sports Med. 2015;49(13):865-70. doi: 10.1136/bjsports-2015-094639
10. Petersen J, Holmich P. Evidence based prevention of hamstring injuries in sport. Br J Sports Med. 2005;39:319-23. doi: 10.1136/bjsm.2005.018549
11. Sole G, Hamren J, Milosavljevic S, Nicholson H, Sullivan SJ. Test-retest reliability of isokinetic knee extension and flexion. Arch Phys Med Rehabil. 2007;88(5):626-31. doi: 10.1016/j.apmr.2007.02.006
12. Furman JM. Posturography: uses and limitations. Baillieres Clin Neurol. 1994;3(3):501-13.
13. Casselbrant ML, Mandel EM, Sparto PJ, Perera S, Redfern MS, Fall PA, et al. Longitudinal posturography and rotational testing in children three to nine years of age: normative data. Otolaryngol Head Neck Surg. 2010;142(5):708-14. doi: 10.1016/j.otohns.2010.01.028
14. Chaudhry H, Findley T, Quigley KS, Ji Z, Maney M, Sims T, et al. Postural stability index is a more valid measure of stability than equilibrium score. J Rehabil Res Dev. 2005;42(4):547-56. doi: 10.1682/JRRD.2004.08.0097
15. Fernandes AA, Silva CD, Costa IT, Marins JCB. The "FIFA 11+" warm-up programme for preventing injuries in soccer players: a systematic review. Fisioter Mov. 2015;28(2):397-405. doi: 10.1590/0103-5150.028.002.AR01
16. Ribeiro RN, Costa LOP. Análise epidemiológica de lesões no futebol de salão durante o XV Campeonato Brasileiro de Seleções Sub 20. Rev Bras Med Esporte. 2006;12(1):1-5. doi: 10.1590/S1517-86922006000100001
17. Silva FM, Silva JAMG, Almeida Neto AF, Salate ACB. Perfil de lesões desportivas em atletas de futsal feminino de Marília. Conscientiae Saúde. 2011;10(2):249-55. doi: 10.5585/ConsSaude.v10i2.2581
18. Jacobson I, Tegner Y. Injuries among Swedish female elite football players: a prospective population study. Scand J Med Sci Sports. 2007;17(1):84-91. doi: 10.1111 / j.1600-0838.2006.00524.x
19. Oda DTM, Ganança CF. Posturografia dinâmica computadorizada na avaliação do equilíbrio corporal de indivíduos com disfunção vestibular. Audiol Commun Res. 2015;20(2):89-95. doi: 10.1590/S2317-64312015000200001469
20. Ergen E, Ulkar B. Proprioception and ankle injuries in soccer. Clin Sports Med. 2008;27(1):195-217. doi: 10.1016/j.csm.2007.10.002
21. Ozenci AM, Inanmaz E, Ozcanli H, Soyuncu Y, Samanci N, Dagseven T, et al. Proprioceptive comparison of allograft and autograft anterior cruciate ligament reconstructions. Knee Surg Sports Traumatol Arthrosc. 2007;15(12):1432-7. doi: 10.1007/s00167-007-0404-y
22. Iwanska D, Karczewska M, Madej A, Urbanik C. Symmetry of proprioceptive sense in female soccer players. Acta Bioeng Biomech. 2015;17(2):155-63. doi: 10.5277/ABB-00243-2014-01
23. Bieć E, Giemza C, Kuczynski M. Changes in postural control between 13-and 19-year-old soccer players: is there a need

for a specific therapy? J Phys Ther Sci. 2015;27(8):2555-7. doi: 10.1589/jpts.27.2555

24. Siqueira CM, Pelegrini FR, Fontana MF, Greve JM. Isokinetic dynamometry of knee flexors and extensors: comparative study among non-athletes, jumper athletes and runner athletes. Rev Hosp Clin Fac Med Univ São Paulo. 2002;57(1):19-24. doi: 10.1590/S0041-87812002000100004
25. Andrews JR, Harrelson GL, Wilk KE. Reabilitação física das lesões desportivas. 3ª ed. Rio de Janeiro: Guanabara Koogan; 2005.
26. Hammami R, Chaouachi A, Makhlouf I, Granacher U, Behm DG. Associations between balance and muscle strength, power performance in male youth athletes of different maturity status. Pediatr Exerc Sci. 2016;28(4):521-34. doi: 10.1123/pes.2015-0231
27. Ambegaonkar JP, Mettinger LM, Caswell SV, Burtt A, Cortes N. Relationships between core endurance, hip strength, and balance in collegiate female athletes. Int J Sports Phys Ther. 2014;9(5):604-16.
28. Mohammadi V, Alizadeh M, Gaieni A. The Effects of six weeks strength exercises on static and dynamic balance of young male athletes. Procedia Soc Behav Sci. 2012;31:247-50. doi: 10.1016/j.sbspro.2011.12.050
29. Young WK, Metzl JD. Strength training for the young athlete. In: Pediatric Annals. 2010;39(5):293-9. doi: 10.3928/00904481-20100422-10
30. Cifrek M, Medved V, Tonkovic S, Ostojic S. Surface EMG based muscle fatigue evaluation in biomechanics. Clin Biomech. 2009;24(4):327-40. doi: 10.1016/j.clinbiomech.2009.01.010
31. Gomes WBM; Bartholomeu Neto J, Assumpção CO, Fraga CHW, Bianco R, Tonello L. Influência da fadiga no equilíbrio do pé de apoio de jogadores de futebol. Rev Bras Educ Fís Esp. 2013;27(1):75-81. doi: 10.1590/S1807-55092013000100008
32. Mello SIL, Lara Junior AA. Interferência do ângulo do pé de apoio no ângulo de saída da bola no chute no futebol com a bola parada. Trabalho apresentado no XII Congresso Brasileiro de Biomecânica; 2007; São Pedro, SP. Porto Alegre: Sociedade Brasileira de Biomecânica; 2007.
33. Pau M, Ibba G, Attene G. Fatigue-induced balance impairment in young soccer players. J Athl Train. 2013;49(4):454-61. doi: 10.4085/1062-6050-49.2.12