DOI: 10.1590/1809-2950/18041428012021

ORIGINAL RESEARCH

Knee flexor and extensor muscles performance comparison in youth team sports with and without jumping

Comparação do desempenho dos músculos flexores e extensores de joelho em jovens de esportes coletivos com e sem salto

Comparación del desempeño de los músculos flexores y extensores de la rodilla en jóvenes en deportes colectivos con y sin salto

Vinícius Jardim Oliano[1], Lilian Pinto Teixeira[2], Juliana Corrêa Soares[3], Michele Forgiarini Saccol[4], Simone Lara[5]

Abstract | This study aims to compare the performance of knee flexor and extensor muscles in young athletes of team sports with and without jumping as specific movement. There were two groups with young male athletes: the jumping group (n 46, volleyball, basketball and handball athletes) and group without jumping characteristics (n=44, futsal and soccer athletes). To evaluate the muscle performance of the flexors and extensors of the knee, we used an isokinetic dynamometer at a speed of 60°/s in concentric mode. The variables analyzed were peak torque normalized by body mass (PT), total work (TW), power (POW) and agonist/antagonist ratio (I:Q). To estimate unilateral deficits, we considered the values of the I:Q ratio less than 50%, and for bilateral deficits, asymmetries between the limbs greater than 10% for PT. There were no significant differences in the performance of knee flexor and extensor muscles between the groups, limbs and their interaction. When comparing significant deficits in PT and in the I:Q Ratio, a greater number of athletes in the jumping group showed imbalances in the I:Q ratio in the dominant limb (58.6% versus 25%, p=0.001). In the intragroup comparison, the group of athletes without jumping characteristics showed a difference between the limbs in the variables PT of extensors and flexors, in the flexors POW and in the I:Q ratio. Young athletes practicing team sports, regardless of the group, showed muscle asymmetries, and we suggest the insertion prevention programs in order to minimize them.

Keywords | Sport Injuries; Muscle Strength; Knee; Athletes.

Resumo | O objetivo deste estudo é comparar o desempenho dos músculos flexores e extensores de joelho em jovens atletas de esportes coletivos que utilizam ou não o movimento do salto como gesto característico. Foram incluídos jovens atletas masculinos alocados em dois grupos: grupo salto (n=46, atletas de voleibol, basquetebol e handebol) e grupo sem características de salto (n=44, atletas de futsal e futebol). Para avaliação do desempenho muscular dos flexores e extensores do joelho, foi utilizado um dinamômetro isocinético na velocidade de 60°/s em modo concêntrico. As variáveis analisadas foram pico de torque normalizado pela massa corporal (PT), trabalho total (TT), potência (POT) e relação agonista/antagonista (I:Q). Para o cálculo dos déficits unilaterais, considerou-se os valores da relação I:Q inferiores a 50% e para os déficits bilaterais, assimetrias superiores a 10% do PT entre os membros. Os resultados indicaram que não houve diferenças significativas no desempenho dos músculos flexores e extensores de joelho entre os grupos, membros e sua interação. Ao comparar

[1]Universidade Federal do Pampa (Unipampa) – Uruguaiana (RS), Brazil. E-mail: magroliano@hotmail.com. Orcid: 0000-0002-1454-2455
[2]Universidade Federal do Pampa (Unipampa) – Uruguaiana (RS), Brazil. E-mail: lipt19@yahoo.com.br. Orcid: 0000-0001-7546-1942
[3]Faculdade Metodista Centenário (FAMES) – Santa Maria (RS), Brazil. E-mail: jjuzinhafisio83@gmail.com. Orcid: 0000-0002-9114-7571
[4]Universidade Federal de Santa Maria (UFSM) – Santa Maria (RS), Brazil. E-mail: michele.saccol@ufsm.br. Orcid: 0000-0002-7894-690X
[5]Universidade Federal do Pampa (Unipampa) – Uruguaiana (RS), Brazil. E-mail: simonelara@unipampa.edu.br. Orcid: 0000-0003-0745-4964

Corresponding address: Simone Lara – Universidade Federal do Pampa, BR 472, km 592 – Uruguaiana (RS), Brazil – ZIP Code: 97508-000 – E-mail: simonelara@unipampa.edu.br –
Funding source: nothing to declare – Conflict of interest: nothing to declare – Presentation: Feb. 24th, 2019 – Accepted for publication: Feb. 5th, 2021. Approved by the Research Ethics Committee: CAAE 74987917.9.0000.5323.

déficits significativos de PT e na relação I:Q, um maior número de atletas do grupo salto apresentou desequilíbrios na relação I:Q no membro dominante (58,6% versus 25%, p=0,001). Na comparação intragrupo, o grupo de atletas sem características de salto apresentou diferença entre os membros nas variáveis PT de extensores e flexores, na POT de flexores e na razão I:Q. Os atletas jovens praticantes de esportes coletivos, independente do grupo, apresentaram assimetrias musculares, e sugere-se a inserção de programas de prevenção de lesão a fim de minimizá-las.

Descritores | Lesões Esportivas; Força Muscular; Joelho; Atletas.

Resumen | El objetivo de este estudio fue comparar el desempeño de los músculos flexores y extensores de la rodilla en atletas jóvenes de deportes de equipo que utilizan o no el movimiento de salto como gesto característico. Se incluyeron a jóvenes deportistas masculinos que se dividieron en dos grupos: grupo de salto (n=46, deportistas de voleibol, baloncesto y balonmano) y grupo sin características de salto (n=44, fútbol sala y fútbol). Para evaluar el rendimiento muscular de los flexores y extensores de la rodilla se utilizó un dinamómetro isocinético a una velocidad de 60°/s en modo concéntrico. Las variables analizadas fueron torque pico normalizado por masa corporal (PT), trabajo total (TT), potencia (POT) y relación agonista/antagonista (I:Q). Para el cálculo de los déficits unilaterales, se consideraron los valores de la relación I:Q inferiores al 50%, y para los déficits bilaterales, asimetrías mayores al 10% del PT entre los miembros. Los resultados indicaron que no hubo diferencias significativas en el desempeño de los músculos flexores y extensores de la rodilla entre los grupos, los miembros y su interacción. Al comparar déficits significativos en PT y en la relación I:Q, un mayor número de atletas en el grupo de salto mostró desequilibrios en la relación I:Q en la extremidad dominante (58,6% versus 25%, p=0,001). En la comparación intragrupo, el grupo de deportistas sin características de salto mostró diferencia entre las extremidades en las variables PT de extensores y flexores, en la POT de flexores y en la relación I:Q. Los deportistas jóvenes que practican deportes de equipo, independientemente del grupo, presentaron asimetrías musculares, por lo que se sugiere la inserción de programas de prevención de lesiones para minimizarlas.

Palabras clave | Lesiones Deportivas; Fuerza Muscular; Rodilla; Atletas.

INTRODUCTION

The practice of sports develops better physical fitness, improves motor performance, socialization and self-esteem, leading more and more young athletes to practice these activities[1]. Despite these benefits, the greater exposure of the athlete to constant repetitive gestures and overloads can lead the athlete to suffer some type of musculoskeletal injure[2]. In this sense, contact sports athletes are more susceptible to injuries, resulting from both the repetitiveness of movement and collisions from sports gestures[3]. Among these movements, the vertical jump is a fast eccentric muscle action movement followed by maximum concentric contraction, requiring great capacity to generate strength and muscle work[4], representing a basic movement in sports such as handball, volleyball, and basketball.

However, studies involving these modalities warn of the relation between vertical jumping and the development of injuries. In the case of volleyball, most injuries occur during the act of jumping[5]. Among recreational basketball players, the ground reaction force during vertical jumping constitutes a significant risk factor for the development of musculoskeletal injuries[6]. Corroborating these findings, biomechanical changes in jumping ability and muscle strength can be found in handball athletes with anterior cruciate ligament injuries[7]. It is noteworthy that the number of jumps varies in each sport modality, so that the soccer athlete has an average of only nine jumps per match, while the basketball player has an average of 65 jumps[8], and the volleyball athlete jumps 150 times[9].

In this sense, participation in intense sports activities leads to specific adaptations, which can generate musculoskeletal changes and thus cause both static and dynamic changes (joint stability and neuromuscular coordination, for example), predisposing the athlete to lesions[10]. Thus, it becomes important to evaluate the strength of the muscles involved in the jump, since this valence allows to identify individuals who are in a risk group for the development of musculoskeletal lesions[11].

The data obtained by the isokinetic dynamometer are useful to characterize the muscular state, since they provide information on strength, power, resistance, and agonist/antagonist ratio (I:Q), and have been reported in studies in different sports modalities[12]. Thus, this study aims to compare the performance of knee flexor and extensor muscles in team sports athletes with jumping versus without jumping as a specific movement.

METHODS

Sample

This is a cross-sectional, descriptive, and quantitative study, which included a convenience sample, formed by amateur athletes of the men's categories Under-15 and Under-17 of volleyball, basketball, handball, futsal, and soccer, competing in the state level. To participate in the study, athletes should have been practicing one of the sports modalities mentioned above for a minimum period of six months and be in regular training, performing only school physical education as another physical activity in addition to their competitive sport. The exclusion criteria were history of orthopedic surgery in the lower limbs and the presence of previous injuries in the lower limbs in the last 12 months, reported by the athlete or through a medical report. The legal guardians signed the informed consent form.

We collected general data such as age, training time, as well as anthropometric data (body mass and height).

The young people composed two groups, being the jumping group (athletes who practiced volleyball, basketball and handball, n=46) and the group without jumping characteristics, composed of athletes who did not have the jump as a specific movement of the sport (futsal and soccer, n=44).

Instruments

An isokinetic dynamometer (*Biodex – System PRO 4*) evaluated muscle performance. Before starting the test, the subjects performed a five-minute warm-up on a cycle ergometer, without load. They were then positioned on the dynamometer, stabilized with belts on the trunk and thigh to avoid compensatory movements, and performed three previous submaximal repetitions to familiarize themselves with the procedures[13]. After, they performed five maximum repetitions of flexion and extension of the knee bilaterally, with an interval of one minute between the series, in which the choice of the first limb to be tested was random. We selected the concentric-concentric mode at a speed of 60°/s, and the athletes received verbal stimulation to develop maximum strength at each repetition[13]. We chose this angular velocity because it is the one indicated for the recruitment of a greater number of motor units, enabling a better representation of the maximum work performed by the evaluated musculature[13].

The variables peak torque normalized by body mass (PT), total work (TW) and power (POW) were analyzed, as well as the agonist/antagonist ratio (I:Q)[14]. To estimate the deficits, we considered the normality values of the I:Q ratio to be 60%[15], and values below 50% indicate a severe degree of muscle imbalance[16]. Regarding the ideal values for bilateral comparisons, we considered asymmetries greater than 10% between the limbs as high risk for injuries[15], which were considered as deficits.

STATISTICAL ANALYSIS

For statistical analysis, we used the SPSS program, version 20.0, with descriptive analysis, through mean and standard deviation measurements. The Shapiro-Wilk test examined the normality of the data. The data followed a normal distribution, and two-factor ANOVA compared groups (with and without jumping characteristics) and limbs (dominant and non-dominant). The T-test performed the intragroup comparison. In addition, to compare the frequencies of dominant limb deficits in extensors and flexors, as well as the percentage of I:Q imbalances in the groups, we used the Chi-square test. All analyses considered a significance level of 0.05.

RESULTS

Table 1 shows the characterization of the sample.

Table 1. Characterization of the sample. Data shown in mean and standard deviation (± SD)

Variable	Jumping group n=46	Group without jumping characteristics n 44	p
Age (years)	15.02 ± 1.10	14.98 ± 1.17	0.68
Mass (kg)	67.64 ± 13.27	63.12 ± 10.47	0.12
Height (m)	1.73 ± 0.08	1.67 ± 0.06	<0.01

Table 2 shows the performance of knee flexor and extensor muscles in the dominant and non-dominant limb of the athletes evaluated. The comparison between groups, limbs, and their interaction did not reveal significant differences.

When comparing muscle deficits between groups, a higher frequency of athletes in the jumping group (58.6%) showed imbalances in the I:Q ratio in the dominant limb, when compared to the group without jumping

characteristics (25%), and this difference between groups was significant (p=0.001).

In the intragroup comparison, the group of athletes without jumping characteristics showed a difference between the limbs in the variables PT of extensors and flexors, in the flexors POW and in the I:Q ratio. The PT of the extensors was higher in the dominant limb (p=0.031), while the PT (p=0.011) and POW (p=0.01) variables of the flexors were higher in the non-dominant limb. The I:Q ratio was also higher in the non-dominant limb of athletes who do not perform jumps.

Table 2. Peak torque (PT in N.m/kg), total work (TW in J), power (POW in W), muscle balance ratio (I:Q in %) and deficits (in %) of knee flexors and extensors in athletes with *versus* without jumping characteristics. Data shown in mean and standard deviation (± SD) and percentage

	Jumping group n 46		Group without jumping characteristics n 44		ANOVA		
	Dominant	Non-dominant	Dominant	Non-dominant	Group	Limb	Interaction
PT extensers	253.86 ± 53.91	248.1 ± 54.11	271 ± 54.82*	260.78 ± 45.62	0.933	0.456	0.903
Deficit extensor PT[a]	45.65		43.18				
PT flexors	134.38 ± 36.37	130.99 ± 55.42	135.26 ± 29.02	141.80 ± 29.11*	0.177	0.794	0.462
Deficit flexor PT[a]	30.43		38.63				
TW extensors	753.30 ± 208.83	741.28 ± 201.11	713.30 ± 208.67	683.02 ± 187.67	0.104	0.483	0.762
TW flexors	402.72 ± 111.48	390.11 ± 105.48	384.37 ± 133.43	388.03 ± 124.28	0.332	0.801	0.647
POW extensors	109.28 ± 29.08	108.6 ± 33.35	111.35 ± 32.79	107.49 ± 28.94	0.972	0.726	0.631
Deficit extensors POW[a]	50		52.27				
POW flexors	58.28 ± 16.26	57.1 ± 15.88	58.63 ± 18.57	61.88 ± 19.07*	0.250	0.532	0.554
Deficit flexors POW[a]	47.82		43.18				
I:Q ratio	52.13 ± 8.67	52.16 ± 13.98	50.50 ± 7.82	54.55 ± 6.97*	0.791	0.164	0.170
I:Q imbalance[b]	58.69[†]	45.65	25	52.27			

[a]Considering deficits greater than 10% in the comparison between the dominant and non-dominant limb[15]; [b]Considering an inadequate ratio below 50%[15]; *Significant difference (p<0.05) in intragroup comparison; [†] Significant difference in intergroup comparison (p=0.001)

DISCUSSION

There was no difference in the performance of knee flexor and extensor muscles in young athletes of team sports with *versus* without jumping. However, a higher percentage of athletes in the jumping group showed a dominant limb I:Q ratio below normal values, which may increase their chance of injury. Despite this difference, it is noteworthy that many athletes in both groups showed values lower than the reference ones, which is approximately 60%[15] at low angular velocities. I:Q ratios below 50% are considered important muscular imbalances[16], becoming a high risk factor for sports injuries. Previous studies have already identified that athletes with ratios less than 50.5% increase the chance of acute muscle injuries[17], especially soccer players[18].

In the study of Magalhães et al.[19], volleyball athletes showed a lower I:Q ratio in the non-dominant limb when compared to soccer players, evaluated at 90°/s speed, unlike our study, in which there was no difference between groups. However, it should be noted that the athletes evaluated by Magalhães et al.[19], were from the adult and professional category, in addition to the difference in the speed used for the isokinetic evaluation. We think that these factors may explain the differences found between the studies. On the other hand, Andrade et al.[20], when comparing soccer, judo and men's handball athletes, identified that judokas showed an I:Q ratio lower than soccer players, without differences between handball and soccer players, which agrees with the data of our study.

In this study, we can verify that the group of athletes without jumping characteristics showed significant asymmetries between limbs in relation to the PT of extensors and flexors, flexors POW and I:Q ratio. These asymmetries in the group of soccer and futsal athletes may be associated with the fundamental characteristics of these modalities, which show asymmetric kinetic patterns[21]. Fousekis, Tsepis and Vagenas[21] found important asymmetries in muscle performance in the lower limbs of young soccer players, possibly due to asymmetric adaptations during the game. Furthermore, the authors draw attention to the fact that preventive measures are inserted in this modality, in order to correct the asymmetries of strength, through the individual modification of the training load.

In addition to the isokinetic evaluation providing data regarding risk factors for possible musculoskeletal injuries, this evaluation is also relevant in the context of

sports performance. In this aspect, both groups showed asymmetries greater than 10% between the limbs in the POW of extensors and knee flexors. According to Fonseca et al.[22], deficits in power at low speed can influence performance in the pullout movement during a match, and therefore this factor should be corrected in training in order to prevent the athlete from losing performance. In this case, it is important to work the POW, especially of knee extensors, in order to avoid loss of sports performance.

Based on these data, we suggest the inclusion of injury prevention programs in young athletes, which aim to reduce uni and bilateral asymmetries. The insertion of these programs aimed at young athletes is extremely significant, because, according to Atkins et al.[23], muscle imbalances, especially bilateral, become striking in early adolescence, and at the end of this stage, these differences seem to reduce. Thus, they suggest that a specific training aimed at alleviating the muscular imbalances of lower limbs in young players contributes to reducing the risk of injuries in these categories.

As a contribution, the data on muscle performance showed in this study can be used as reference values in the prevention, training and rehabilitation of young athletes.

CONCLUSION

There was no difference in the performance of knee flexor and extensor muscles in team sports athletes with and without jumping characteristics. However, the jumping group showed a greater number of athletes with severe muscular imbalances in the I:Q ratio in the dominant limb.

In intragroup comparisons, soccer and futsal athletes showed higher PT in the dominant extensor group and in the non-dominant limb flexor variables. Based on these findings, these sports seem to influence muscle performance values.

REFERENCES

1. Wenger DRMD. The Sports Medicine Bible for Young Athletes. J Pediatr Orthop. 2002;22(4):559. doi: 10.1097/01241398-200207000-00033
2. Knowles SB, Marshall SW, Bowling JM, Loomis D, Millikan R, Yang J, et al. A prospective study of injury incidence among North Carolina High School Athletes. Am J Epidemiol. 2006;164(12):1209-21. doi: 10.1093/aje/kwj337
3. Santos SG, Piucco T, Reis DC. Fatores que interferem nas lesões de atletas amadores de voleibol. Rev Bras Cineantropom. Desempenho Hum. 2007;9(2):189-95.
4. Lian O, Engebretsen L, Ovrebo RV, Bahr R. Characteristics of the leg extensors in male volleyball players with jumper's knee. Am J Sports Med. 1996;24(3):380-5. doi: 10.1177/036354659602400322
5. Eerkes K. Volleyball injuries. Curr Sports Med Rep. 2012;11(5):251-6. doi: 10.1249/JSR.0b013e3182699037
6. Kilic Ö, Van Os V, Kemler E, Barendrecht M, Gouttebarge V. The 'Sequence of Prevention' for musculoskeletal injuries among recreational basketballers: a systematic review of the scientific literature. Phys Sports Med. 2018;46(2):197-212. doi: 10.1080/00913847.2018.1424496
7. Setuain I, Millor N, Alfaro J, Gorostiaga E, Izquierdo M. Jumping performance differences among elite professional handball players with or without previous ACL reconstruction. J Sports Med Phys Fitness. 2015;55(10):1184-92.
8. Rocha CM, Ugrinowitsh C, Barbanti VJ. A especificidade do treinamento e a habilidade de saltar verticalmente: um estudo com jogadores de basquetebol e voleibol de diferentes categorias. Lect EF Deportes. 2005;10(84):[1 p.].
9. Rocha MA. Quantificação do número de saltos de ataque, bloqueio e levantamento no voleibol feminino [dissertação]. Universidade de São Paulo: São Paulo; 2010.
10. 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 Sao Paulo. 2002;57(1):19-24.
11. 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
12. Andrade MS, Vancini RL, de Lira CA, Mascarin NC, Fachina RJ, da Silva AC. Shoulder isokinetic profile of male handball players of the Brazilian National Team. Braz J Phys Ther. 2013;17(6):572-8. doi: 10.1590/S1413-35552012005000125
13. Bittencourt NFN, Amaral GM, Anjos MTS, D'Alessandro R, Silva AA, Fonseca ST. Avaliação muscular isocinética da articulação do joelho em atletas das seleções brasileiras infanto e juvenil de voleibol masculino. Rev Bras Med Esporte. 2005;11(6):331-6. doi:10.1590/S151786922005000600005
14. Terreri AP, Greve JMD, Amatuzzi MM. Avaliação isocinética no joelho do atleta. Rev Bras Med Esporte. 2001;7(5):170-4.
15. 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
16. Andrews JR, Harrelson GL, Wilk KE. Reabilitação física das lesões desportivas. 3a ed. Rio de Janeiro: Guanabara Koogan; 2005.
17. Lee JWY, Mok KM, Chan HCK, Yung PSH, Chan KM. Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. J Sci Med Sport. 2018;21(8):789-93. doi: 10.1016/j.jsams.2017.11.017

18. Ardern CL, Pizzari T, Wollin MR, Webster KE. Hamstrings strength imbalance in professional football (soccer) players in Australia. J Strength Cond Res. 2015;29(4):997-1002. doi: 10.1519/JSC.0000000000000747

19. Magalhães J, Oliveira J, Ascensão A, Soares J. Concentric quadriceps and hamstrings isokinetic strength in volleyball and soccer players. J Sports Med Phys Fitness. 2004;44(2):119-25.

20. Andrade MS, De Lira CA, Koffes FC, Mascarin NC, Benedito-Silva AA, Da Silva AC. Isokinetic hamstrings-to-quadriceps peak torque ratio: the influence of sport modality, gender, and angular velocity. J Sports Sci. 2012;30(6):547-53. doi: 10.1080/02640414.2011.644249

21. Fousekis K, Tsepis E, Vagenas G. Multivariate isokinetic strength asymmetries of the knee and ankle in professional soccer players. J Sports Med Phys Fitness. 2010;50(4):465-74.

22. Fonseca ST, Ocarino JM, Silva PLP, Bricio RS, Costa CA, Wanne LL. Caracterização da performance muscular em atletas profissionais de futebol. Rev Bras Med Esporte. 2007;13(3):143-7. doi: 10.1590/S1517-86922007000300003

23. Atkins SJ, Bentley I, Hurst HT, Sinclair JK, Hesketh C. The Presence of Bilateral Imbalance of the Lower Limbs in Elite Youth Soccer Players of Different Ages. J Strength Cond Res. 2016;30(4):1007-13. doi: 10.1519/JSC.0b013e3182987044