ANALYSIS OF THE FUNCTIONAL KINETIC PERFORMANCE OF MMII OF A GROUP OF AMATEUR RUNNERS FROM THE MUNICIPALITY OF GURUPI, Brazil

ABSTRACT

Aims: The objective of this study was to evaluate the functional kinetic performance of a group of amateur runners from the municipality of Gurupi-To through the application of the passive stiffness test of the lateral rotators of the hip, Y Balance Test, dorsiflexion lunge test, Navilicular drop test, and sit-and-reach test (Wells bank test).
Study design: This was a cross-sectional, quantitative field research.
Place and Duration of Study: Data collection was carried out from February 2024 to March 2024.
Methodology: The research was carried out at the Clinical School of Physiotherapy of the University of Gurupi (UnirG) in the municipality of Gurupi with amateur runners associated with Tonello AssessorialSportive.
Results: The research revealed that the sample presents a balance deficit in the lower limbs, bilateral hypomobility of the ankle, low flexibility of the posterior chain, overweight and obesity, preserved hip and ankle mobility and physiological plantar arch for normality.
Conclusion: Therefore, overweight and low scores in injury incidence tests in the group of runners.

Keywords: Functional Physical Performance; Biomechanics; Race; Sports Injuries; Musculoskeletal Pain.

1. INTRODUCTION

Running is a sport that has been highly sought after by various profiles of participants in recent times. It is an attractive physical activity due to its easy access, which can be performed individually and/or in groups, low cost and the various benefits that the regular practice of it can bring to the individual, such as improved insulin sensitivity, reduction of total cholesterol, LDL (low density lipoprotein), triglycerides, gain of lean and bone mass, in addition to allowing the promotion of health, aesthetics, social integration and reduction of daily stress [1].

However, although running is beneficial, inadequate performance, high volume of exercise during the week, high BMI (Body Mass Index), history of previous injuries and lack of physical preparation can cause the reappearance of these old injuries and promote the emergence of new dysfunctions [2].

These lesions may be associated with intrinsic and extrinsic factors. The intrinsic ones are directly related to the patient, encompassing age, gender, experience, aptitude and other aspects, while the extrinsic ones integrate training, type of activity, climatic conditions, among others, directly or indirectly influencing the appearance of injuries in athletes [3].

A meta-analysis published in 2019 found that the knee is the region with the highest prevalence of injuries, muscle trauma is the type of injury with the highest incidence among street runners, and the gender that is most likely to suffer from it is male [4]. Another cross-sectional study, carried out between 2020 and 2022 in Minas Gerais,

found that in the target audience of the research, the greatest complaints were pain in the knee region, followed by ankles, calves, heels, and posterior thighs [5].

Among the various musculoskeletal pathologies that affect runners, the main ones are patellar tendinopathy, patellofemoral dysfunction, medial tibial stress syndrome, plantar fasciitis, calcaneal tendon tendinopathy and iliotibial band syndrome, with patellar tendinopathy being the pathology that has the highest incidence rate, being caused by an imbalance of forces between the thigh muscles, of the hip and core, which overload the knee and lower limb, especially during running [5].

Therefore, it is of paramount importance to evaluate for the early diagnosis of functional kinetic dysfunctions and to apply functional tests to evaluate the performance of runners [6].

Functional tests are extremely important to evaluate the athlete's performance due to the level of demand that they recruit for their execution, since they are close to the demand that physical activity needs for its action, thus allowing to more reliably detect possible functional dysfunctions, such as biomechanical and postural misalignments that can directly affect the performance of these individuals [7,8].

In this context, the interest was aroused in evaluating, through the application of the passive stiffness test of the lateral rotators of the hip, Y Balance Test, dorsiflexion lunge test, navicular drop test, and sit-and-reach test (Wells bank test), the functional kinetic performance of a group of amateur runners from the municipality of Gurupi-TO and thus be able to evaluate the flexibility. to evaluate the balance, proprioception and mobility of the lower limbs of amateur runners, to identify functional deficits that may later trigger future injuries and to detect the predominance of low scores in the tests in relation to gender, age, weekly frequency, physical fitness and time of sports practice (months/year).

2. MATERIAL AND METHODS

This was a cross-sectional, quantitative field research. As this is research involving human beings, it was submitted to and approved by the Research Ethics Committee under Substantiated Opinion No. 6,573,679 and CAAE No. 76444923.0.0000.5518.

The research was carried out at the Clinical School of Physiotherapy of the University of Gurupi (UnirG) in the municipality of Gurupi with amateur runners associated with Tonello Assessorial Sportive. The inclusion criterion was all runners linked to Tonello Assessorial Sportive who were available to go to the place designated for data collection on the pre-established dates and times. The exclusion criteria were: individuals who did not attend on the scheduled dates and times, those who did not agree with the Free and Informed Consent Form, and runners with an acute injury. After applying the inclusion and exclusion criteria, 28 amateur street runners were evaluated.

Data collection was carried out from February 2024 to March 2024. The evaluations were carried out on Mondays for six weeks, from 6:00 p.m. to 9:40 p.m., at the Physical Therapy School Clinic of UnirG. There were 5 meetings evaluating 5 individuals and 1 evaluating 3.

Data were collected using an evaluation form developed by the authors. It was divided into two stages: the questionnaire and the application of the tests. In the first stage, there were questions such as the runner's age, gender, weight, how long they had been running, how often they trained, whether they performed flexibility, mobility or strength gain exercises, whether they had followed up with a health professional, their history of competitions and injuries. The second stage was the application of the Medial Hip Rotation Assessment Test, Navicular Fall Test, Y Balance Test (YBT) Dorsiflexion Lunge Test (DLT), and Sit-and-Reach Test (Wells Bench).

During the evaluation, we also used an iPhone XR smartphone from Apple that already had the inclinometer installed, two rolls of 3M school masking tape of 24mmX50 meters, four rubberized tape measures from the Círculo brand of 150 centimeters, a Wells bench from the brand BALLKE, two marker brushes for whiteboard from the brand Pillot, a ream of 75-gram A4 paper with 100 sheets of Chamequinho for the printing of the evaluation forms and two orthopedic goniometers in PVC with a dimension of 200X45mm of the Trident brand.

The results obtained through the evaluation were computed as percentages, means, and standard deviations in the Microsoft Excel 2019 application. The data presented in tables.

3. RESULTS AND DISCUSSION

The research was carried out in the city of Gurupi – TO, a total of 28 amateur street runners who met the inclusion criteria were evaluated. The sample consisted of 6 males and 22 females. Table 1 describes the general characteristics of the sample evaluated. According to the data collected, the profile of amateur runners in greater quantity was female, with an average age of 38.8 years, weighing 72.4 kilograms, with a practice time of 62.3 months, with a frequency of training of 3.3 times a week, participating in 6.2 competitions. In addition, it was possible to perceive that women are classified as overweight, and men as obese. In perception, women have been running longer than men, however, men compete more times a year than women.

Table 1. Characteristics of the samples.

	Men (n=6)	Women (n=22)	Sample (n=28)
		Average ± SD	
Age (years)	37,5 ± 12,0	39,2 ± 8,9	38,8 ± 9,4
Weight (kg)	91,2 ± 22,7	67,3 ± 8,6	72,4 ± 15,9
BMI	30,4 ± 5,9	25,1 ± 2,7	26,2 ± 4,1
Practice time (months)	29,6 ± 31,8	70,1 ± 52,8	62,3 ± 51,6
Frequency of workouts (days)	3,8 ± 1,0	3,2 ± 0,9	3,3 ± 0,9
Annual Competition Frequency	9,2 ± 8,9	5,4 ± 3,5	6,2 ± 5,2

**Source: Primary data (2024).*

Table 2 describes characteristics related to road running. According to the table, a greater number of patients reported being monitored by a health professional and running in groups. In addition, 57.1% of the sample reported having suffered some type of injury while running. Most perform strengthening, mobility, and flexibility training.

Table 2. Features related to street racing.

	Men (n=6)		Women(n=22)		Sample (n=28)	
	Yes	No	Yes	No	Yes	No
Follow-up of training with a professional	5	1	19	3	24	4
Run in groups	3	3	20	2	23	5
Had injury due to running	3	3	13	9	16	12
Perform flexibility training	6	0	22	0	28	0
Perform mobility training	5	1	20	2	25	3
Perform strengthening workouts	5	1	21	1	26	2

**Source: Primary data (2024).*

Among the lesions mentioned by the sample, there were reports of plantar fasciitis, muscle strain, tendinopathies, low back pain, bursitis, chondromalacia patellae and shin splints. They mentioned physical therapy as an ally in the recovery of the injury process, which among the physical therapy procedures submitted were myofascial release and ozone therapy. Among the professionals mentioned, the sample revealed that they follow up with physical education professionals, physiotherapists, orthopedists and cardiologists.

Regarding flexibility, assessed through the application of the sit-and-reach test (Wells Bench), Table 3 shows, by percentage, that 60.7% of the runners are classified as below average/poor. Only one runner was rated as excellent.

Table 3. Flexibility rating.

Classification	Men (n=6)	Women(n=22)	Sample (n=28)
Bad	33,3% (2)	31,8% (7)1	32,1% (9)
Below average	33,3% (2)	27,3% (6)	28,6% (8)
Average	-	22,7% (5)	17,9% (5)
Above average	33,3% (2)	13,6% (3)	17,9% (5)
Excellent	-	4,5% (1)	3,6% (1)

**Source: Primary data (2024).*

From the application of the medial hip rotation test, it was evidenced that the subjects evaluated presented values within the reference range (table 4).

Table 4. Medial Hip Rotation Test Result.

	Men (n=6)	Women(n=22)	Sample (n=28)
Lower limb Law	33,66º ± 9,47	36,81º ± 8,97	36,14º ± 9,00
Lower limb Left	32,66º ± 5,95	37,09º ± 7,96	36,14º ± 7,70

**Source: Primary data (2024).*

Table 5 shows the results of the Dorsiflexion Lungue Test. According to what was collected, the mean of the total hallux-wall distance sample was 7.62 centimeters (cm) on the right side and 7.30 cm on the left side, showing similarity in relation to both sides and distance. Correlating the degrees and distances achieved, it was noticed that the group of runners presented a predominance of bilateral ankle hypomobility.

Table 5. Result of the Dorsiflexion Lungue Test.

		Men (n=6)	Women(n=22)	Sample (n=28)
Distance (cm)	Right lower limb	7,17 ± 3,18	7,75 ± 2,35	7,62 ± 2,50
	Lower limb Left	6,83 ± 3,60	7,43 ± 2,47	7,30 ± 2,69
Degrees	Right lower limb	33,66 ± 3,18	34,22 ± 5,35	34,35 ± 4,92
	Lower limb Left	32,66 ± 5,00	34,54 ± 4,44	34,10 ± 4,55

**Source: Primary data (2024).*

Table 6 shows the results detected with the navicular drop test. It was observed that, with weight unloading, no differences greater than 1 centimeter were observed in the plantar arch bilaterally.

Table 6. Navicular Drop Test Result.

		Men (n=6)	Women(n=22)	Sample (n=28)
Discharged (cm)	Right lower limb	5,20 ± 0,44	7,75 ± 2,35	7,62 ± 2,50
	Lower limb Left	5,16 ± 0,68	7,43 ± 2,47	7,30 ± 2,69
No Discharge (cm)	Right lower limb	5,58 ± 0,66	34,22 ± 5,35	34,35 ± 4,92
	Lower limb Left	5,66 ± 0,87	34,54 ± 4,44	34,10 ± 4,55
Difference (cm)	Right lower limb	0,58 ± 0,66	0,47 ± 0,35	0,49 ± 0,42
	Lower limb Left	0,50 ± 0,44	0,41 ± 0,32	0,43 ± 0,34

**Source: Primary data (2024).*

Tables 7 and 8 show the data collected from the Y Balance Test. Table 7 shows the distances achieved by the runners and the composite score obtained. The total sample showed a mean composite score of 82.82% in the right lower limb and 83.43% in the left lower limb. This demonstrated that those evaluated are at risk of developing lower limb injuries.

Table 7. Balance test result Y.

		Men (n=6)	Women (n=22)	Sample (n=28)
Limb length (cm)	Right lower limb	90,83 ± 7,73	85,36 ± 4,14	86,55± 5,44
	Lower limb Left	91 ± 7,66	85,95 ± 4,44	86,60 ± 5,49
Previous Average (cm)	Right lower limb	58 ± 10,77	56,09 ± 8,02	57,14 ± 8,47
	Lower limb Left	57,28 ± 11,99	56,5 ± 9,32	57,28 ± 9,55
Posterolateral Media (cm)	Right lower limb	90,16 ± 5,77	80,16 ± 13,77	81,85 ± 13,45
	Lower limb Left	90,33 ± 5	79,79 ± 12,52	81,57 ± 12,52
Posteromedial Media (cm)	Right lower limb	86,83 ± 6,82	73,54 ± 13,93	75,71 ± 13,99
	Lower limb Left	87 ± 6	73,04 ± 19,08	75,21 ± 18,47
Compound Score (cm)	Right lower limb	86,67 ± 9,99	82 ±10,95	82,82 ± 10,99
	Lower limb Left	85,83 ± 9	82 ± 11	83,43 ± 11

**Source: Primary data (2024).*

Table 8 shows the asymmetry in each direction assessed by the test. Through it, it was detected that the posteromedial direction has a predictive value of injury and the posterolateral direction presented values indicative of attention.

Tabela 8. Result of the Asymmetry Y Balance Test.

	Men (n=6)	Women (n=22)	Sample (n=28)
Previous (cm)	3,16 ± 1,32	2,77 ± 2,89	2,85 ± 2,62
Previous (cm)	1,50 ± 1,64	4,45 ± 3,31	3,82 ± 3,25
Posteromedial (cm)	1,83 ± 1,16	4,77 ± 2,75	4,14 ± 2,77

Source: Primary data (2024).

Running, according to McGuinnis, "is a cyclical activity consisting of alternating periods of one-legged support (contact phase) and no support (air or flight phase)." It is a physical activity that has been practiced for many centuries and, because it is an activity that is easy to perform, low cost and brings health benefits when practiced correctly, the demand for it has increased a lot over the years. However, with the increase in the number of runners, the incidence of musculoskeletal injuries has also increased, whether due to excessive overload, prolonged repetitive efforts or lack of preparation for the start of running [9,10].

Through the body mass index (BMI) found in the sample evaluated, it was possible to perceive that women are classified as overweight, and men as obese. Obesity and overweight, according to the literature, is a risk factor for the appearance of lesions. Ulusoy et al and Bi and Jang, in their studies, detected that there is a relationship between weight and associated joint injuries, such as medial and/or lateral meniscus tears and bone hematomas, and that the joints with the highest risk are the knee, ankle-foot, lumbar spine and shoulder [11,12].

Among the lesions mentioned by the sample, there were reports of plantar fasciitis, muscle strain, tendinopathies, low back pain, bursitis, chondromalacia patellae and shin splints. These data are similar to those found in a meta-analysis carried out in 2019, in which the total sample history was that the prevalence of muscle injuries, strains, and contractures was 27.9%; ligament injuries, such as sprains and dislocations, were 27.8%; plantar fasciitis, tendinitis, synovitis, bursitis, and medial tibial stress syndrome (shin splints), grouped as inflammatory lesions, with a prevalence of 26.5%; and bone lesions included fracture, chondromalacia patellae, and bone edema, with a prevalence of 5.6% [4].

The sit-and-reach test (Wells Bank) has an ICC of 0.97, according to Cardoso et al [13]. The test, for Inchauspe, assesses the flexibility and range of motion (ROM) of the posterior chain and trunk according to [14]. De Araújo et al mentioned that increased flexibility and range of motion play an important role in the conservation of tendons and ligaments when they are impacted during running, preventing the appearance of tendinopathies [8]. The survey revealed that 60.7% of the population evaluated was classified as poor and below average. Only one runner was rated as excellent. According to Becker et al, reduced flexibility associated with other biomechanical factors in ankle dorsiflexion predispose to the appearance of tendon and musculoskeletal lesions in the tibialis anterior muscle [15]. Flexibility in running, according to Norberto and Puggina (2019), is of paramount importance in the conservation of tendons and ligaments that suffer direct impact during activity, thus exerting a protective effect on the runner [16].

According to Bittencourt et al, the medial hip rotation test is used to evaluate the ROM of internal rotation of the hip joint by measuring passive hip stiffness with a reference value between 30º and 40º, with an intraclass correlation coefficient (ICC) of 0.99 and a standard error of measurement (SEM) of 1.5° [17]. Leite et al reported that a value lower or higher than this mean directly interferes with the biomechanics of the entire lower limb, increasing the risk of injuries such as knee ligament ruptures and patellofemoral pain syndrome [18]. The mean values in the group were within the normal range, 36.14º in the right lower limb (standard deviation of ± 9.00) and 36.14º in the left lower limb (standard deviation of ± 7.70).

The Dorsiflexion Lunge Test (DLT), for Manoel, is a test that evaluates the range of motion of ankle dorsiflexion, since reduced ankle mobility is a risk factor for sprains and patellar tendinopathy. It describes that the evaluated individual should keep the hallux at a distance of 10 centimeters from the wall [19]. Konor et al argue that, in addition to the distance within the reference values, the subject must have desirable joint mobility above 45º. His research detected that the test has an ICC of 0.96 to 0.99 using the measuring tape and the inclinometer [20]. The test revealed bilateral dorsiflexion restriction in the group of runners with small discrepancies between the two limbs.

The Navicular Fall Test, according to Sabino, is used to observe the excessive or not pronation of the foot, through the fall of the navicular bone at the moment when weight bearing occurs, has an ICC of 0.93 and a typical measurement error of 2.16 millimeters [21]. Dillon et al argued that the fall should not exceed 10 millimeters (mm), values above which predispose to injuries such as Achilles tendinopathy and medial tibial stress syndrome (shin splints) [22]. The group presented data within the reference range, thus having a lower risk of developing lesions.
The Y Balance Test, in the view of Neto et al, evaluates the dynamic balance of athletes and physically active people, indicating the risk of ankle and knee injuries, since imbalances during the execution of the race can increase the risk of fractures and increase the chances of the athlete developing degenerative injuries and ankle sprains[7] . Powden et al., in their study, determined ICC OF 0.88 for the anterior direction, 0.88 for posteromedial

and 0.90 for posterolateral [23]. Nunes et al used 95% as a reference value for the composite score for the non-appearance of lesions and the mean difference in range less than 4 centimeters in each direction evaluated. According to them, a composite score below the benchmark increases the chances of injury by 6.5 times. Range difference values above the reference increase the chances of injury by 2.5. They point out that each direction shows weakness in a specific direction. In the anterior direction, there is muscle weakness of the quadriceps, hamstrings, and gastrocnemius. In the posteromedial direction, it determines muscle weakness of the gluteus medius, tibialis anterior and peroneus. Posterolateral muscle weakness of the gluteus maximus, lateral rotators, and hamstrings [24] is indicated. The total sample showed a mean composite score of 82.82% in the right lower limb and 83.43% in the left lower limb, presenting a high risk of developing lesions in the lower limbs. Regarding the direction, posteromedial showed predictive value of lesion and posterolateral showed values indicative of attention.

According to Pavan, in order to be able to detect dysfunctions and injuries installed, prevent the emergence of new alterations and draw up an appropriate treatment plan for them, it is necessary to carry out a kinetic-functional evaluation, since through it it is possible to make the necessary corrections to restore the athlete's function [25]. Evaluation, in McGuinnis' view, can be both quantitative and qualitative, when the evaluation of performance or any of its aspects is based only on the senses of the examiner it can be said to be qualitative, however, when performance or any of its aspects are quantified or measured the evaluation is called quantitative [9].

Through a functional quality assessment using reliable tests, it is possible to detect lesions, evaluate functionality and, thus, determine an appropriate treatment for each individual. Silva points out that the physiotherapist has a very important role in promoting health in athletes, whether they are professionals, amateurs or the general public, as he acts both in the prevention of injuries and in the treatment of those that are already installed so that these athletes can enjoy their physical activities without discomfort [26].

Overload is a factor that predisposes to the appearance of lesions, since most of them had a high BMI. Another contributing factor was the low flexibility associated with joint hypomobility. In addition, it is worth noting that, even doing flexibility, mobility and muscle strengthening training in order to improve the function of the lower limbs during sports practice and prevent injuries, the body can be injured due to overloads of other activities of daily living not associated with running.

4. CONCLUSION

Through this research, it is concluded that the sample has balance deficit in the lower limbs, bilateral hypomobility of the ankle and low flexibility of the posterior chain, in addition to overweight and obesity. The population showed preserved hip and ankle mobility and physiological plantar arch to normality. Therefore, overweight and low test scores can be associated with the incidence of injuries in the group of runners.

The research was of great value for evidencing the reality of the functional kinetic performance of the lower limbs of the group of amateur runners evaluated and to obtain a concrete view of the probability of injury risk.

REFERENCES

1. Gonçalves GH. Street running: A study on the reasons for adhesion and permanence of amateur runners in Porto Alegre. Porto Alegre; 2011.

2. Barbosa RO. Most common injuries in athletics, in the modality of cross-country running, in athletes from the city of Campina Grande-PB. 2010. 45f. Course Completion Work (Graduation in Physical Education). Campina Grande; 2010.

3. Incidence of injuries in street runners and associated factors: A systematic review. Rev Intercont Gest Desportiva [Internet]. 2022; Available: http://dx.doi.org/10.51995/2237-3373.v12i1e310045

4. Borel WP, Elias Filho J, Diz JBM, Moreira PF, Veras PM, Catharino LL, et al. Prevalence of injuries in Brazilian recreational street runners: Meta-analysis. Rev Brasil Med Esporte [Internet]. 2019;25(2):161–7. Available: http://dx.doi.org/10.1590/1517-869220192502214466.

5. Silva AT. Identification of the lower limb injury profile of street runners in the city of Uberlândia-MG. 2023. 21 f. Course Completion Work. Uberlândia; 2022.

6. Vieira CEN, Carvalho AR, Natur VHS. Evaluation of lower limb alignment and musculoskeletal factors in street runners. RBPFEX-Brazilian Journal of Exercise Prescription and Physiology. 2020; 89:147–58.

7. Neto, HP Rossi, MF; Bonvino, MA et al. Scales and functional tests in orthopedic, neurological and respiratory physiotherapy. 1st ed. Sorocaba, São Paulo: Eduniso, 2021.

8. De Araújo HS, Hayasi EO, Ito TG, Gomes ARS, Zotz TGG, Macedo ACB de. Musculoskeletal function and prevalence of lower limb injuries in street runners in Curitiba, Brazil. Physical Education and Sport Notebook. 2022 Jun 21;20.

9. McGinnis PM. Biomechanics of Sport and Exercise - 3rd ed. Artmed Publishing House; 2015.

10. RUNNING BIOMECHANICS AND INJURIES RESULTING FROM MOVEMENT ERRORS: A LITERATURE REVIEW | Ibero-American Journal of Humanities, Sciences and Education. periodicoreaseprobr [Internet]. 2022 Aug 1 [cited 2024 Apr 27]; Available: https://periodicorease.pro.br/rease/article/view/6395

11. Ulusoy GR, Kızılgöz V, Sivrioğlu AK. Relationship between Body Mass Index and Articular Injuries Accompanying Primary Anterior Cruciate Ligament Tear in Male Knees: A Retrospective Observational Study. J Knee Surg. 2020 Nov;33(11):1157-1162. doi: 10.1055/s-0039-1692668. Epub 2019 Jul 8. PMID: 31284322.

12. Bi W, Yang M, Jiang C. Causal effect of body mass index and physical activity on the risk of joint sports injuries: Mendelian randomization analysis in the European population. J Orthop Surg Res. 2023 Sep 12;18(1):676. doi: 10.1186/s13018-023-04172-y. PMID: 37700350; PMCID: PMC10496185.

13. Inchauspe R. Evaluation and Functional Testing. 2021.

14. Cardoso J, Azevedo N, Cassano C, Kawano M, Âmbar G. Intra- and interobserver reliability of hip angular kinematic analysis during the sit-and-reach test to measure hamstring length in university students. Braz J Phys Ther [Internet]. 2007Mar; 11(2):133–8. Available: https://doi.org/10.1590/S1413-35552007000200008

15. Becker J, James S, Wayner R, Osternig L, Chou LS. Biomechanical Factors Associated With Achilles Tendinopathy and Medial Tibial Stress Syndrome in Runners. Am J Sports Med. 2017 Sep;45(11):2614-2621. doi: 10.1177/0363546517708193. Epub 2017 Jun 5. PMID: 28581815.

16. Norberto MS, Puggina EF. Relationships between lower limb flexibility and injury rate in resistance modalities. Rev Bras CiêncEsporte [Internet]. 2019Jul; 41(3):290–7. Available: https://doi.org/10.1016/j.rbce.2018.05.003

17. Bittencourt NF, Ocarino JM, Mendonça LD, Hewett TE, Fonseca ST. Foot and hip contributions to high frontal plane knee projection angle in athletes: a classification and regression tree approach. J Orthop Sports Phys Ther. 2012 Dec;42(12):996-1004. doi: 10.2519/jospt.2012.4041. Epub 2012 Sep 18. PMID: 22990391.

18. Leite DX, Vieira JMM, Carvalhais VOC, Araújo VL, Silva PLP, Fonseca ST. Relationship between passive joint stiffness and concentric torque of the lateral rotators of the hip. Braz J Phys Ther [Internet]. 2012Sep;16(5):414–21. Available: https://doi.org/10.1590/S1413-35552012005000046

19. Manoel LS. Identification of risk factors for ankle injuries in professional soccer players through a functional assessment in the pre-season period. 2020

20. Konor MM, Morton S, Eckerson JM, Grindstaff TL. Reliability of three measures of ankle dorsiflexion range of motion. Int J Sports Phys Ther. 2012 Jun;7(3):279-87. PMID: 22666642; PMCID: PMC3362988.

21. Sabino GS, Rocha IC, Guimarães CQ, Alcântara MA de, Felício DC. Analysis of the reliability of the clinical test of navicular fall. Fisioter mov [Internet]. 2012Apr;25(2):301–9. Available: https://doi.org/10.1590/S0103-51502012000200007

22. Dillon S, Burke A, Whyte EF, O'Connor S, Gore S, Moran KA. Running towards injury? A prospective investigation of factors associated with running injuries. PLoS One. 2023 Aug 17;18(8):e0288814. doi: 10.1371/journal.pone.0288814. PMID: 37590281; PMCID: PMC10434952.

23. Powden CJ, Dodds TK, Gabriel EH. The reliability of the star excursion balance test and lower quarter y-balance test in healthy adults: a systematic review. Int J Sports Phys Ther. 2019 Sep;14(5):683-694. PMID: 31598406; PMCID: PMC6769278.

24. Nunes LB, Borges AP, Rodrigues BRF, Franco FS, De Carvalho LAN, Pires VCMC, et al. Aimportância do Y Balance Test comopreditivo de lesõesembailarinas / The importance of the Y Balance Test as a predictor of ballerina injuries. Brazilian Journal of Development. 2021 Jun 22;7(6):61814–28.

25. Pavan, FV.Physico-Functional Assessment and Imaging. 1ª ed. Idaial: UNIASSELVI, 2019.

26. RepositórioInstitucional da Cogna [Internet]. repositorio.pgsscogna.com.br. [cited 2024 May 8]. Available: https://repositorio.pgsscogna.com.br//handle/123456789/41961

20. Ramskov, D., Rasmussen, S., Sørensen, H., Parner, E. T., Lind, M., & Nielsen, R. Interactions between Running Volume and Running Pace and Injury Occurrence in Recreational Runners: A Secondary Analysis. Journal of Athletic Training, 2022 57(6), 557–563. Available:https://doi.org/10.4085/1062-6050-0165.21

DEFINITIONS, ACRONYMS, ABBREVIATIONS

N: number of respondents
Kg: kilograms
SD: standard deviation
BMI: Body Mass Index
Cm: centimeters